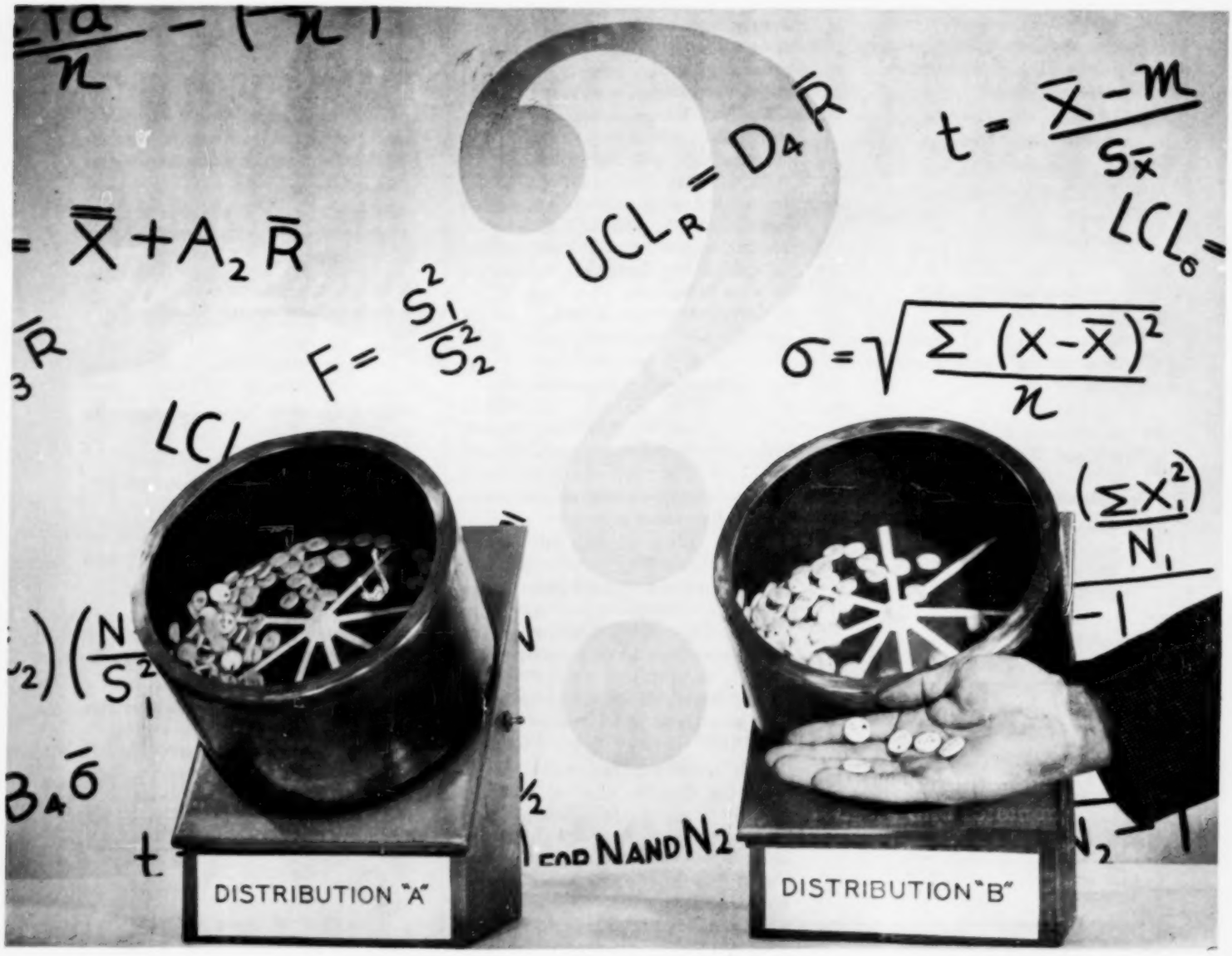
Industrial QUALITY CONTROL

VOL. VI NOVEMBER, 1949 NO. 3



MECHANICAL CHIP MIXERS — (See page 3)

AMERICAN SOCIETY FOR QUALITY CONTROL

INDUSTRIAL QUALITY CONTROL

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MECHANICAL CHIP MIXERS

R. E. WAGONHALS

The Timken Roller Bearing Co.

Use of chip mixers similar to those shown in the cover picture add drama to the demonstration of any statistical principles which are explained by the use of numbered chips. The continuous mixing of chips attracts and holds the attention of large audiences and speeds up any chip demonstration by mixing the chips rapidly and thoroughly. Tests show that random samples are obtained when samples are taken, read, returned to the mixer and another sample taken immediately.

A mixer is constructed by mounting a 78 R.P.M. phonograph motor (shaft ground down to get a turn table speed of 48 R.P.M.) on a wooden base at a 53½ degree angle with the horizontal. The drum is 9" dia. by 4½" high with a ½" lip to prevent the chips from falling out during the mixing. To reduce the noise of the chips against the metal drum, it is lined with velvet cloth. A 140 degree included angle cone is placed on the face of the turn table and covered with velvet to insure a thorough, rapid mix. This mixer is designed to mix 200 - ⅜" dia. by 3/32" thick chips, but quantities from 50 to 300 can be mixed without affecting the randomness too greatly.

Effective demonstrations with these mixers are:

(1) Showing the necessity of using an adequate amount of data for F and t tests by taking one sample of 5 from each distribution, calculating F and t and then accumulating more data by taking additional samples of 5 from each distribution. The distributions we have used generally show significance at the one percent level after data from twenty chips are calculated. It is very seldom that significance at the 5% level is found between the two distributions based upon data from the first five chips from each.

(2) Showing how control charts operate in control when chips are drawn from the mixer and $\bar{X}$ and R or $\bar{X}$ and σ charts are constructed. A dramatic demonstration can be made by showing how the charts operate in control with the regular distribution and then adding a few out of tolerance chips to see how many samples have to be drawn before the charts show out of control. In this demonstration it usually takes only two to three samples until out of control is shown.

(3) Chips of a rectangular or triangular distribution are drawn in groups of four or more. A histogram of the averages shows a distribution approaching the normal curve.

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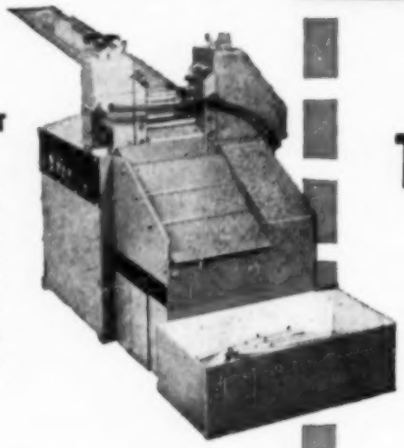

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Practical Applications of New Theory
A Review
PART II–COUNTED DATA–GRAPHICAL METHODS

FREDERICK MOSTELLER and JOHN W. TUKEY

HARVARD UNIVERSITY PRINCETON UNIVERSITY

We shall not repeat the introduction to this series given in Part 1,* except to remind the reader that we are presenting new methods, some of which have not been tried in industrial work. In the present article we take up methods of treating counted data and graphical methods. Among these are the use of transformations, sensitivity testing, special graph papers, methods of measuring association between two characteristics, and testing changes in percentages in the matched case.

COUNTED DATA

Recent developments in handling counts, as opposed to measurements, have concentrated on transformations and related graphical procedures. These allow effective tests without detailed tables. The classical transformations are the angular transformation for binomial data, introduced 25 years ago by R. A. Fisher, and the square-root transformation for Poisson data, introduced 13 years ago by M. S. Bartlett, which is the limiting case of the angular transformation for p small.

In the Poisson case, the original adjustments introduced by Bartlett ["The square-root transformation in the analysis of variance," Suppl. J. Roy. Stat. Soc. 3 (1936) 68-78] have been compared with others by F. J. Anscombe ["The transformation of Poisson, binomial and negative-binomial data," Biometrika 35 (1948) 246-254] and M. F. Freeman and J. W. Tukey ["Transformations related to the angular and the square-root," Memorandum Report 24, SRG Princeton University, submitted to the Annals of Math. Statistics]. If the purpose of the transformation is to make the variance nearly independent of the mean, then

$$\sqrt{\text{number}} + \sqrt{\text{one} + \text{number}}$$

has unit variance (and hence unit standard deviation) within 6% for means of unity or more. For making significance tests, treat the following as normally distributed with unit variance (and hence unit standard deviation):

Is observed high?

$$2[\sqrt{\text{observed}} - \sqrt{\text{expected}}]$$

Is observed low?

$$2[\sqrt{\text{expected}} - \sqrt{\text{one} + \text{observed}}]$$

These will give very good results from expectations of 4 upwards.

There is an entirely similar set of transformations in the binomial case. (For variance stabilization see Freeman and Tukey's paper cited above.) For comparing an observed and an expected proportion, treat the following as normally distributed with unit variance (and hence unit standard deviation)

Is observed number of defectives high?

$$2[\sqrt{(1-p)\cdot(\text{defect.})} - \sqrt{p(\text{one} + \text{nondefect.})}]$$

Is observed number of defectives low?

$$2[\sqrt{p(\text{nondefect.})} - \sqrt{(1-p)\cdot(\text{one} + \text{defect.})}]$$

where p is the expected fraction defective.

All of these tests may be made simply and graphically with special graph paper ("Binomial probability paper" available from the Codex Book Company, Norwood, Mass., No. 31,298 on thin paper, No. 32,298 on thick paper) which is based on a suggestion of R. A. Fisher and K. Mather ["The inheritance of style length in Lythrum Salicaria," Annals of Eugenics 12 (1943) 1-23]. The application of this principle to control charts for population defective when the lot size is variable has already been discussed in this journal by Acheson J. Duncan ["Detection of non-random variation when size of sample varies," Industrial Quality Control 4 (1947-8) 9-12]. A large variety of uses has been discussed by Frederick Mosteller and John W. Tukey ["The uses and usefulness of binomial probability paper," Jour. Am. Stat. Ass'n. 44 (1949) 174-212].

RANKING METHODS FOR STUDYING ASSOCIATION

The classical way to use the ranks of a sample where the objects are ordered according to two characteristics to seek evidence of association was to calculate the rank correlation (due to Spearman; sometimes called R, which we will use, and sometimes called by the Greek letter rho). The method and formula is given in most statistics textbooks, for example G. W. Snedecor [Statistical Methods, Collegiate Press, Ames, Iowa, 1946, a good reference work but most of the problems and examples treated there are biological and agricultural]. Maurice G. Kendall proposed ["A new measure of rank correlation," Biometrika 30 (1938-9) 81-93] the measure tau:

$$\frac{(\text{pairs in same order}) - (\text{pairs in opposite order})}{\text{number of possible pairs}}$$

* IQC, September 1949, pp. 5-8.

If n is the number of objects the number of pairs is

$$K = n(n-1)/2.$$

For example if we have 10 objects and no ties, the arrangement for the two characteristics x and y might be

x: 1 2 3 4 5 6
y: 3 2 6 5 4 1.

We can always arrange one of the variables in ascending order, but this is not necessary, nor is ranking necessary. Pairs of y in the same order as x are 36, 35, 34, 26, 25, 24; in the opposite order 32, 31, 21, 65, 64, 61, 54, 51, 41. Note that K is $15 = (6)(5)/2$, so tau is

$$\frac{6-9}{15} = -0.2.$$

There is some evidence of negative association between x and y.

Kendall conjectured that the correlation between R and tau, in random sampling from a population with no association, was very close, that the correlation coefficient failed to reach the value +1, corresponding to perfect agreement, by less than $\frac{1}{4}n$. H. E. Daniels ["The relation between measures of correlation in the universe of sample permutations," Biometrika 33 (1943-6) 129-135] has shown that this is the case. Thus it will almost always be reasonable to use whichever coefficient is more easily calculated. This is often tau, for reasons explained by Kendall [Biometrika 33 (1943-6) 250].

In our example R is —0.14 and for samples of size 6 we expect such close agreement because the correlation between R and tau is more than 0.96.

The usefulness of these measures of association in industrial work depends very much on the ease and effectiveness with which ties can be allowed for. Kendall ["The treatment of ties in ranking problems," Biometrika 33 (1943-6) 239-251] has reexamined this problem and concludes that, for the situations most common in industrial practice, where the ties are due to limited accuracy of judgment, measurement, and recording, no adjustment need be made to tau, while R should be adjusted by the method indicated by Woodbury ["Rank correlation when there are equal variates," Annals of Math. Stat. 11 (1940) 358-362] who gives tables. (When comparing judges, etc., a different adjustment, first used by Student in 1921, should be made.) This is an additional reason for using tau.

A CORNER TEST FOR ASSOCIATION

A quick test of association between two variables for those who like graphs and little computation has been provided by P. S. Olmstead and J. W. Tukey ["A corner test for association, Annals of Math. Stat. 18 (1947) 495-513]. One makes a scatter diagram and draws a horizontal line through (between) the middle y value (s) and a vertical line through the middle x value. Think of the four quadrants or corners thus formed as being labelled +, —, +, —, in order, so that the upper right and lower left quadrants are positive. Beginning at the right hand side of the diagram, count in (in order of abscissae) along the observations until forced to cross the horizontal median. Write down the number of observations met before this crossing, attaching the sign + if they lay in the + quadrant, and the sign — if they lay in the — quadrant. Repeat this process moving up from below, moving to the right from the left, and moving down from above. The quadrant sum is the algebraic sum of the four terms thus written down. The 5% and 1% significance levels are given by quadrant sums of at least 11 and 14 respectively. This technique is quicker to use than to explain. The authors provide a diagram which is almost self-explanatory. Devices for handling ties and other minor vexations are given. The method is extended for use on serial correlation and on more than two variables.

SENSITIVITY TESTING

The class of techniques known as sensitivity testing in the explosives field and as quantal bioassay in pharmacology is already in use in testing laminated materials for strength and is being considered for fatigue testing. The essentials are a set of different severities, and counts of the number failing at each level.

For many purposes, particularly biological ones, it is reasonable to suppose that the probability of failure is related to severity just as the probability of a normally distributed quanity being less than x is related to x. The case where a fixed number of objects is tested at each of a preassigned set of levels can be analyzed graphically with the aid of normal probability paper, or more delicately by the methods expounded in D. J. Finney's book [Probit Analysis: A Statistical Treatment of the Sigmoid Response Curve, Cambridge University Press, 1947].

When it is easy to change the severity of the test applied to individual objects in accordance with the results of previous cases (dropping weights on explosives, or balls on safety glass are examples) then it is more efficient to use the "up-and-down" technique, where severity is decreased one notch after each success. W. J. Dixon and A. M. Mood ["A method for obtaining and analyzing sensitivity data," J. Am. Stat. Ass'n. 43 (1948) 109-126] have discussed the advantages of this method and the details of its analysis. More complex methods of the same sort have been studied by T. W. Anderson, P. J. McCarthy, and J. W. Tukey ["Staircase methods of sensitivity testing," NAVORD report 65-66, prepared by SRG Princeton University, March 21, 1946] and the effects of non-normality have been investigated by D. F. Votaw, Jr. ["The effect of non-normality on "Staircase" methods of sensitivity testing," Report prepared under Navy Contract N60nr-270, Task I by SRG Princeton University, May 1, 1949].

NEW GRAPH PAPERS FOR SENSITIVITY WORK

Joseph Berkson has designed three new graph papers to aid in sensitivity work. All are available from the Codex Book Co., Norwood, Mass. Most of us are familiar with what is commonly called arithmetic probability paper (a misnomer). This graph paper has a linear scale and a cumulative normal scale. By plotting points of a distribution function on such paper we can get a good idea whether our curve is approximately normal or not because normal cumulatives appear as straight lines on this paper. Berkson provides such a paper (31,451) on thin paper, 32,451 on heavy paper), but his has two advantages, the normal scale is on the short side of the paper, and one can get back the normal deviate from an additional scale. Another such probability paper based on the cumulative logistic curve (31,450 on thin paper, 32,450 on heavy paper) relieves us from always using the normal and gives us another reasonable curve to try. The logistic often represents growth curves and sensitivity curves better than the normal. The third graph paper (31,452 on thin paper, 32,452 on heavy) transforms from x to the inverse sine function. Again, straight lines tell us whether this is a reasonable

transformation. The fourth graph paper has normal scales in both directions (32,453 on heavy paper) and may prove useful for such purposes as designing single sampling plans by interpolation among known cases, and in other cases where two probabilities depend on a choice (another case has been described by Berkson [J. Am. Stat. Ass'n. 42 (1947) 246]).

McNEMAR'S PROCEDURE FOR CORRELATED PROPORTIONS

In connection with testing the reliability of inspectors in classifying product as defective or non-defective, two questions which arise are: (1) does the inspector change the severity of his inspection? (2) how does the severity of one inspector compare with that of another? A test recently suggested by McNemar [Psychological Statistics, John Wiley & Sons, 1949, 77-82] for psychological work and extended by Bowker [J. Am. Stat. Ass'n. 43 (1948) 572-4] can be applied.

Suppose we run the same lot of items through two different inspectors, recording in each case whether an item was classified as defective or non-defective. Then we can draw up a 2x2 table as follows:

		Inspector I		
		Non-defective	Defective	Total
Inspector II	Non-defective	420	10	430
	Defective	30	40	70
	Total	450	50	500

We are interested in knowing whether Inspector II is the more severe (or alternatively Inspector I more lax) in his inspection process. We really want to compare 430 with 450 and 70 with 50. However the problem is complicated by the correlation induced by the agreement between the observers. It turns out that we should really compare the upper right and lower left hand corners of the 2x2 table for equality using the formlua for t:

$$\frac{\textbf{one less than pos. differ. of disagreeing cells}}{\sqrt{\textbf{sum of disagreeing cells}}}$$

For our example

$$t = \frac{30-10-1}{\sqrt{30+10}} = 3.00.$$

Here t is a normal deviate, and we have confidence that the inspectors are working at different severities because of the 3-sigma difference observed. The —1 is a correction for continuity. It is important to notice that this problem is different from testing association in a 2x2 table and has been mishandled by many people who understand the latter.

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Quality Reports to Management*

AUGUST B. MUNDEL

CHIEF ENGINEER, QUALITY CONTROL AND INSPECTION DIVISION, SONOTONE CORPORATION

INTRODUCTION

When the title of this paper was originally selected, the subject was confined to reports from the Quality Control and Inspection Division to top management. After further consideration, it was decided that this was too narrow an interpretation of the title. All quality reports to foremen and plant managers are reports to management and in some respects may be more important than quality audits to management.

The scope of this discussion has, therefore, been broadened and will include

(a) A discussion of the underlying principles and purposes of reports.
(b) Several examples of reports to operating management.
(c) A discussion and example of a quality audit as typified by a Customer Quality Report.

In some plants the emphasis in quality control is to reduce costs and increase production. Our efforts are not opposed to these economies but our real goal is quality improvement, quality maintenance and quality standardization. Of course, good quality and high shrinkage cannot coexist and, therefore, we do watch shrinkage closely. Our plant produces aids for the hard of hearing. Our method of doing busines domestically is to sell at retail through some 300 directly controlled outlets throughout the nation. Any instrument proving unsatisfactory within one year of sale to the customer is replaceable for a factory rebuilt and reconditioned instrument of the same type at any office. Our greatest economy is obtained when we reduce the number of these free exchanges in the field. Because of this our products must have uniform quality when they are purchased and must remain so during service. A large volume of our business is directly traceable to references furnished by satisfied users. The value of quality in increasing the number of such references is impossible to measure. Our efforts are therefore directed toward improving the uniformity and increasing the service life of hearing aids.

* Presented at the Second Annual Convention, ASQC, and Fourth Annual Rochester Clinic, Rochester, N. Y., February 17, 1948.

TO: Mr. A. B. M.

FROM: Mr. R. L. S.

SUBJECT: Raw Material Inspection Department - Weekly Progress Report (Week ending December 20, 1947)

COPY TO: Messrs. L.C.M., E.W., P.S., J.D., N.T., S.R.

PART NUMBER	NAME	QUANTITY REC'D	QUANTITY ACCEPTD	DETAILED	AQQL	PROCESS AVERAGE
4-S-1	Battery	5184	5184		2%	0
6004	Lugs, plt.	34000	34000		2%	0
6050	Rivets, plt.	26823	26823		2%	0
6050	Rivets	26823	26823		2%	0
6252-1	Women's battery support	900	900		2%	0
6284	Pins, plt.	15033	15033		2%	0
6284	Pins	15033	15033		2%	0
6286	Pins, plt.	21265	21265		2%	0
6301-3	Diaphragms	2500	2500		2%	0
6339	Spring contact	19997	19997		2%	0
6347	Screws	81600	81600		2%	0
6415	Sapphire needles, Mfr. A	636	0		2%	75%
6415	Sapphire needles, Mfr. B	10300	8327		2%	14.9%
6535	Voltmeters	13	7	X	2%	23%
6566-1	Condenser	8231	8231		1%	0
6566-2	Condenser	13940	13940		1%	0
6567	Tube sockets	3820	3350	X	2%	2.1%

FIGURE 1 — RAW MATERIAL INSPECTION REPORT

Since our concern is with quality per se the reports are not cost conscious. In some other instance the emphasis might be on cost, quality, or man hours.

PRINCIPLES OF QUALITY REPORTS

1. It is important to know the interest of management when preparing a report. Emphasize the things that are important for management to know—this is the first fundamental of quality control reports. It would be unthinkable to post a control chart in a department which has no interest or connection with an item. Reports are similar; they must be of interest and concern to the executive before they get action.

2. The second fundamental is to circulate the reports and data. Get the information to manufacturing before it has cooled off . A report prepared and held in a desk does not inform anyone.

In addition, a report may be less influential if it is produced at someone's request than if regularly prepared and issued. To illustrate, let me tell you an experience which occurred during one of our regular meetings with top management. Mr. S. remarked that several comments had been received from the sales staff that the sensitivity of a certain instrument had deteriorated since the first production. I pointed out that the essential information to answer the complaint was in a regularly issued Customer Quality Report. When taken from Mr. S's file it proved that the initial quality was unchanged. The fact that the data were in Mr. S's file was a psychological advantage.

Week April 21-26 part	# passed	ave. group size	#groups tested	#groups accepted 1st	#groups accepted 2nd	#groups rejected 1st	#groups rejected 2nd	AOQL table used	process avg. result of first sample
"700 Test Lots #298 - #315	1899	106	18	17	1	0	0	5%	0.5%
"700" Transmitters-ind. op. test	1933	55	35	34	1	0	0	5%	0.3%
"700" Battery cords	505	102	5	4	1	0	0	5%	2.1%
"700 Oscillator cords	2626	525	5	5	0	0	0	5%	0.0%
"700" receiver cords	1040	260	4	4	0	0	0	5%	0.0%
"700" wired chassis	1582	99	16	15	1	0	0	2%	0.0%
"700" fronts	1522	381	4	3	1	0	0	1%	1.1%
"700" backs	469	235	2	2	0	0	0	1%	0.0%
"700" battery comp'ts.incompl.	1452	309	6	5	0	1	0	2%	8.4%
"700" battery comp'ts.complete	1350	338	4	4	0	0	0	4%	0.0%
"700" battery box covers	2964	593	5	5	0	0	0	2%	0.0%
"700" cord housing	2710	678	4	4	0	0	0	2%	0.4%

FIGURE 2 — CONTROL GROUP WEEKLY SUMMARY REPORT

Having the data in the hands of the questioner, before the question is asked, is always more assuring to the investigator that the data were not collected merely to prove the point in question. In addition, it shows that control is being exercised.

Another value which accrues to circulated reports—especially those that circulate to operating personnel—is the interest engendered by their landing on the desk, the oportunity to discover errors in data as well as in the operation, and in the tacit agreement implied by their acceptance. Interested parties will point out errors in reports that concern work in their department.

A somewhat similar incident is typified by the protest of a factory engineer that the dimensional tolerances could not be held on Item X. The control charts which had been regularly maintained and "posted" beside the machine in the department of "Item X" showed that control had existed for a period of several weeks. Once he had been shown and convinced that the tolerances had been held, he was able to regain control in a few hours.

3. The third fundamental in writing reports is to be concise, and to the point. Time is too precious to waste in long descriptions where specific statements, graphs or technical terms cover the situation more precisely. There are cases where the technical description is involved and only an engineer can understand it. The alternative of spending several pages to explain the situation may appeal to some. It has been our feeling that above all else the report must be accurate. That means that accurate technical language must be used

TO: Mr. A. P. M.
FROM: Mr. J. L.

700 DAILY SHRINKAGE REPORT
WEEK BEGINNING APRIL 14, 1947
MONTH OF APRIL 1947

FIRST RUN

		DAILY SHRINKAGE M.	T.	W.	T.	F.	ACCUMULATED THIS MONTH M.	T.	W.	T.	F.
Final Test	Tested	357	250	382			3237	3487	3869		
	Shrkg.	65 18%	38 15%	45 12%			556 17%	594 17%	639 17%		
Batty. Compt.	Tested	459	416	377			4317	4733	5110		
	Shrkg.	9 2%	16 4%	27 7%			187 4%	203 4%	230 4%		
Batty.* Covers	Tested	65	32	36			436	468	504		
	Shrkg.	2% 0	2% 0	2% 0			2% .5%	2% .4%	2% .4%		
Batty. Cords	Tested	361	409	434			3877	4286	4720		
	Shrkg.	12 3%	14 3%	14 3%			108 3%	122 3%	136 3%		
Batty.* Cord Covers	Tested	-	-	-			392	392	392		
	Shrkg.	- -	- -	- -			2% 2%	2% 2%	2% 2%		
Oscl. Cords	Tested	271	99	375			1209	1308	1683		
	Shrkg.	0 0	0 0	5 1%			0 0	0 0	5 .2%		
Air Rec. Cords	Tested	364	562	-			4604	5166	5166		
	Shrkg.	0 0	3 .5%	- -			66 1%	69 1%	69 1%		

ms
cc: Messrs. J.L., L. G. H., G.K., A.J., P.S., R.N., E.W.

*Amount Submitted	
A.Q.Q.L.	Process Av

FIGURE 3 — DAILY SHRINKAGE REPORT

even if some explanation is to follow. Reports are written to assist the control of quality and are meant to assist the man on the job to correct or improve his procedure and not to point out that he is getting too much shrinkage or doing a bad job. The report must, therefore, be precise enough to give the engineer an accurate quantitative review of the situation.

4. Fundamental four is that reports must be factual, must not upset departments, groups or individuals by needless accusation of carelessness or malpractice. The only result of such accusations is to create ill will. A statement of actual conditions without comment is much more to the point—just state the facts, but be constructive if possible.

A statement that 3% of the instruments had loose parts needs little if any interpretation. In one case a fraction defective control chart posted in the factory for the first time showed screws missing from 3% of the product. This alone resulted in the disappearance of this shrinkage factor.

In another case a statement in the regular Customer Quality Report that the average response was below specification average for the past two months but had previously agreed with the specification average brought corrective action.

5. The fifth fundamental is regularity of reports. Regularity is essential in maintaining control charts. In a like manner regularity in reports eliminates bias. Reports which are not regularly issued will be prepared when changes take place. Either the results are improved or trouble has occurred. A regular review of subjects eliminates this bias and prevents the criticism that reports convey the impression that normal conditions never occur. If conditions are normal a report issued at specified intervals must find control existing at least occasionally if control exists at all.

Regularity is also a hard task master and the fact that you have committed yourself or your department to issue a regular report sets a more definite goal and forces a review of the subject at these times. We are all likely to procrastinate. A report that is issued later than scheduled annoys us. Thus the regular report discourages procrastination.

EXAMPLES OF REPORTS

A review of some of the reports used in our plants will assist in emphasizing the fundamentals just discussed. Since

This report summarizes data on the quality of material shipped to the field during the month of November 1947.

The data for this report was obtained from random samples representing first run quality, customer quality or indicated stage in production.

During this month, shipments of 900 instruments were made to the field. The AOQL (Average Outgoing Quality Limit) of the "900" as well as the "700" transmitter and components was maintained at 5%.

The first page of this report contains a general discussion of the quality levels of the materials listed in detail in this report.

The data used as a basis for this report has been the work of many individuals. It represents a summary of data taken both in the laboratory and in the factories by members of the Quality Control and Inspection Division.

Prepared by

Quality Standards Group

August B. Mundel
Chief Engineer
Quality Control &
Inspection Division
Sonotone Corporation
Elmsford, N.Y.
December 10, 1947

cc:	Messrs.	I.I.S.	J.L.
		L.C.H.	A.M.L.
		J.H.	G.B.
		H.A.P.	E.O.
		E.W.	A.W.
		C.R.	M.E.
		J.C.	H.L.
		H.K.	H.R.J.
		K.C.	J.C.
		S.I.P.	H.F.K.

FIGURE 4 — COVER PAGE—MONTHLY CUSTOMER QUALITY REPORT

The "900" and "700" Instruments - The first "900" instruments were shipped to the field during the month of September. The average output of the instruments manufactured up to the end of September is shown in this report. The specification, as originally set, calls for an average output of 156 millivolts at 1.4 volts "A" and 22 1/2 volts "B". The average of the manufactured product is running at 143 millivolts. Under these conditions, it is 0.8 db below the specification average but well within the limit of 100 to 250 millivolts. At 15 volts, the specification calls for an average of 67 millivolts but the product is running at an average of 56 millivolts output. This output is 1.6 db below the specification average but well within the specification limits. This data is being presented in the form of a control chart similar to that which has previously been used for summarizing the response of the "700". The "700" instrument has continued to perform at the same average level as shown in the August report.

Tubes - P-4's completing life test during the month of September were much more stable than those which completed life test during the month of August.

Definitions - Definition of Customer Quality - Where the characteristic of an instrument or component in this report is listed as the Customer Quality, samples have been taken after the material has passed inspection and would normally go to the field. The samples are then indicative of the quality which our dealers and customers would obtain.

Definition of First Run Quality - First run quality is the quality after a component, assembly or completed instrument has been finished but before it has been tested. It is natural to find defects in first run quality which would not be present in customer quality because they have been removed in the inspection process.

FIGURE 5 — SUMMARY PAGE—MONTHLY CUSTOMER QUALITY REPORT

"700" INSTRUMENT PERFORMANCE

The chart on this page shows the output readings obtained at full "A" battery voltage (1.4 volts) and 17 volts of "B" battery. The output readings are in millivolts and represent the output into a 100 ohm load when the instrument is measured in the final test box at 600 cycles with approximately 60 db above a zero level of 0.0002 dynes/cm^2 sound pressure on the microphone.

Average values ($\bar{X}$) and sigmas (σ) on these charts represent samples selected at random from instruments which have been approved for shipment (i.e. Customer Quality). Samples are selected and inspected independently of production by the Quality Control Group at the Hamilton Plant at the beginning of each week. The chart shows the variation of $\bar{X}$ and σ, by weeks from September 29th to the present. The dotted lines represent control limits and the solid lines $\bar{\bar{X}}$ and $\bar{\sigma}$. On the chart the $\bar{X}$ for November 10th and November 24th were outside their control limits indicating that these samples were unlike previous groups. In general this would indicate that outgoing quality was not as well controlled statistically in November as in October. However, output limits of sets shipped have been maintained within specifications in all cases. The specification limits are the same as those initially used.

Weekly Averages - "700" Instrument Measured at Control Group - Customer Quality

Output @ 17 and 1.4 volts Specifications: 50-178 mv.

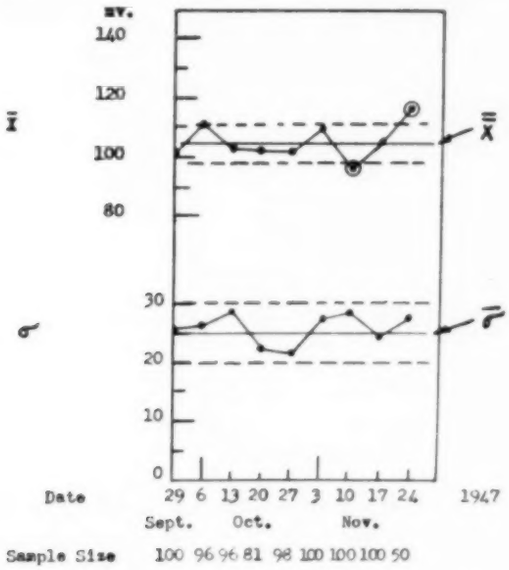

FIGURE 6 — USE OF CONTROL CHART IN CUSTOMER QUALITY REPORT

the subject matter of reports is in general of a confidential nature within an organization, many of the reports have been altered so as to contain no confidential material.

Figure 1 presents the regular report of the foreman of the Raw Material Inspection Group showing the parts that have been received and inspected in the last week. A short report usually accompanies this, pointing out details of unusual or administrative items. Here the emphasis is on quality with a listing of the AOQL and the process average of material inspected. This report is issued weekly—it is brief and factual. Note for example, part No. 6415 received from two different manufacturers, also the "X" when detailing was necessary. Here the report is of interest to associated departments such as the Purchasing Department and the Manufacturing Division. Copies are also sent to the Chief Mechanical Engineer and the Divisional Heads.

Figure 2 shows the Weekly Summary Report on interplant subassemblies and final products presented by the factory quality control group. This indicates the process average defective and the quantity of materials passed by the group from one plant or department to another, or shipped to the customer. The control group in our plant does all sampling of subassemblies and finished parts. When quality reaches a satisfactory limit all 100% inspection ceases except where lots fail sampling.

Shrinkage reports, Figure 3, are another form of report to management. Here the report is issued to all interested individuals.

This report, which covers first run quality, (first run quality being the quality at any point in the process prior to an inspection operation) lists daily shrinkages on the left. One column is used for each day of the work week (Monday, Tuesday, etc.) and cumulative shrinkages for the month are on the right half of the sheet. Referring to the chart, the upper line for each item is the total presented for test, the lower left item the shrinkage, and the lower right item the percent of shrinkage. Similarly, for the accumulated values on the right of the sheet. Where parts have qualified for sampling, the items are marked with an asterisk and the AOQL and process average are shown as in the code box at lower right. These reports are made on ditto. One stencil is used for a week starting Monday. When the first set of columns is completed, copies are sent to those on the circulation list. Additional data are inserted on the stencil each successive date and copies immediately printed and sent out.

One of the big advantages of recording several day's shrinkage and the accumulated shrinkage on a single sheet, as in these shrinkage records, is the possibility of observing whether or not statistical control exists in the shrinkage record. In locations where a more current shrinkage record is required, these records supplement hourly shrinkage records which are kept in greater detail on each factory test set.

THE CUSTOMER QUALITY REPORT

Reports to top management in our organization are more formal and are issued monthly rather than daily or weekly as are the previous reports. Here we expect no immediate action or response to the report whereas reports at operating level usually contain items which require prompt action by some individual.

The Customer Quality Report contains an overall picture of operating efficiency and quality level. It is circulated to the top management: the President, Director of Technical Operations, Sales Department, Treasury Department, as well as responsible personnel in all of the operating divisions. In issuing and circulating a report of this nature it is, of course, necessary to have tacit executive approval and cooperation. In addition, it is wise to pay scrupulous attention to the principles previously set forth, or the goal of better quality will not be achieved. This report should give further incentive to better quality. In addition to keeping our management

informed of plant operations and quality levels, it has taught them what variations to expect in the product. A complete copy of this report would be too long for this paper. Several specimen sheets will be shown and described. With these as a guide it should be possible to adapt this procedure to your needs.

Figure 4 shows a cover page from one of our monthly quality audits. The cover gives a circulation list and a short resumé of pertinent facts. Also note the formal title, the persons responsible for issuing the report, and a reference to divisional personnel who have collected the data. Reports should always show their source of origin, a subject and a date. They may be addressed to the immediate superior and include a distribution list. Where not specifically addressed, a distribution list should be included. (It is sometimes amazing to see the number of reports which circulate in an organization without listing authors or responsible departments.)

Figure 5 shows the summary sheet of the report. Here, as in some other places in this article, all the information appearing on a single sheet is not drawn from one report but from several to give clearer examples. The purpose of the summary sheet is to give all a quick resumé and refer them more rapidly to their particular interest.

In this report you will note references to AOQL, histograms, control charts and symbols such as $\bar{X}$ and σ. Our practice has been to use statistical terms and quality control forms whenever they best describe the situation. In this way accuracy is maintained and specific information is given to Research, Engineering and operating personnel. For the benefit of the lay reader a short general definition of the new term or form is given at the appropriate point, as, for example, the definition of first run and customer quality on the summary sheet.

As an example of the use of a control chart in the Customer Quality Report let us refer to Figure 6. This chart indicates the electrical output of a hearing aid under a specific test condition. The level of operation of this instrument is of interest to our management and is, therefore, included in this report. In this case, control limits are close together because of a large sample size. A state of control does not exist at every point shown on the chart. The last point on the $\bar{X}$ chart covers a smaller sample size than the previous

RECEIVERS

The average of R1 receivers checked in the Quality Standards Section was very close to the specification average. All readings were within the specification limits and the readings were distributed almost fifty-fifty above and below the specification average.

The shrinkage on the R1's for the month was 12% out of 2161 produced.

Customer Quality-R1 Receiver Response at 400 Cycles

0 db = Specification average of 97 db above .0002 dynes/cm^2 into a standard 2 cc. coupler with a 6 μw. drive into an equivalent load of 64 ohms.

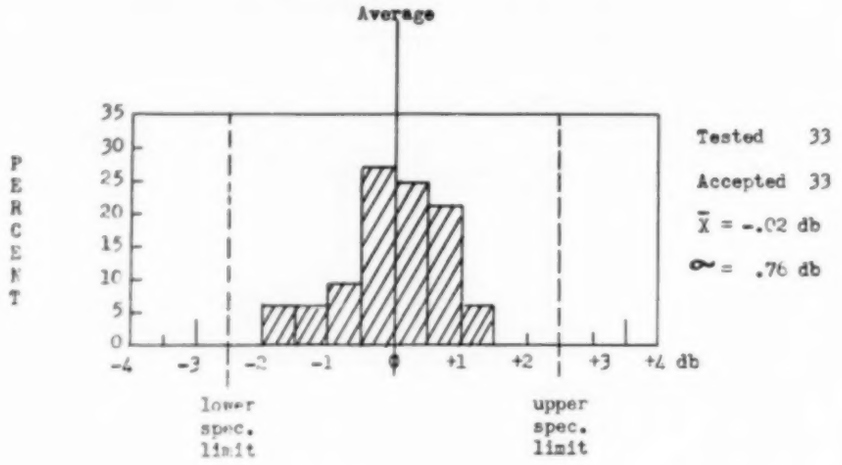

FIGURE 7 — USE OF HISTOGRAM IN CUSTOMER QUALITY REPORT

averages. Since computation of the actual control limits for this sample size shows the point to be out of control, the control limits were not adjusted. Specification limits are carefully indicated. A statement explaining the cause of the loss of statistical control should be included.

A short description of the chart accompanies it for those unversed in statistical terminology. Each instrument type of major interest may be described by one or several charts of this type indicating various parameters and conditions of operation.

The next sheet of the Customer Quality Report (Figure 7) is an example best described by a histogram. The report shows the performance of hearing aid receivers in reference to specification levels. The criterion is how much sound pressure is obtained in a specified cavity when a specific electrical power input is available. Reference is made to this specification above the histogram. The initial publication of histograms was accompanied by a short description but this form of presentation is almost self-explanatory.

Shrinkage figures at final test for the month may be included at this point or in the summary. It is also of interest insofar as customer quality is concerned to point out changes in mechanical or operational features in these descriptions whenever such occur.

CONCLUSION

The problem in each plant is different and so are the interests. As a quality reporter you must know the problems, the points of view and how best to portray the important characteristics. Since such a discussion must take into account the actual conditions involved, it is, of course, beyond the scope of this paper.

Our quality reports have materially helped to create a mutual responsibility. Reports are a management tool and, if wisely used, create a better understanding of the desired goal and a more unified effort toward its attainment.

In conclusion, we shall restate the principles we have discussed:

1. Report items of major importance.
2. Circulate your report at least to your superior and, if possible, to your associates and interested parties.
3. Be brief and specific.
4. Be factual and unbiased.
5. Issue reports regularly.

ACKNOWLEDGEMENT

The leadership of Dr. L. Grant Hector of the Sonotone Corporation and the encouragement of Dr. Ellis Ott have in a large measure been responsible for the work reported herein and the development of an integrated Quality Control and Inspection Division at the Sonotone Corporation.

A New Method for Approving a Machine or Process Setting—Part III

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INTRODUCTION

The first two papers in this series* provided a general approach to the problem of checking a machine or process setting. They included tables of constants which would enable the user to check the setting, subject to two risks of wrong decisions. These constants had to be multiplied by the process standard deviation before the checking could begin. This paper presents sets of tables already prepared so that if one knows the process standard deviation or the average range, he can immediately begin his check without any arithmetic, by simply using the appropriate table. Thus this paper goes one step further in simplifying the checking of a setting.

DESCRIPTION OF TABLES

Table 1 of this paper was obtained directly from Table 3 of Part I in this series of papers. The range of all possible process standard deviations, σ', from 1 to 10 was broken up into twelve intervals, each covering approximately a twenty percent variation in (σ')'s. The respective values of L and U of Table 3 (Part I) were multiplied by the largest value of σ' in each interval. This gives the acceptance and rejection number for each sample size, n, if the process standard deviation lies in the interval shown. Thus if a process standard deviation is .0023", we call this 2.3 thousandths and arrange to record the measurements in thousandths, so that σ' will be between 1 and 10. (We do not measure in ten thousandths of an inch for then σ' would be equal to 23 of these units.) Next we choose the interval of σ' running from 2.155 to 2.610 since it contains 2.3. The acceptance and rejection numbers are then given in the corresponding columns, the unit being thousandths of an inch.

Such a check is designed to distinguish between process averages of 2.61 thousandths of an inch apart, as shown in the first row of the headings in the table. This means that if we should check the setting when it is actually perfect there is somewhat less than one chance in ten of reaching the incorrect decision of "reset." On the other hand if the setting is checked when it is actually 2.61 thousandths of an inch too high or too low, the undesirable decision of "approve" stands to be reached less than one time in ten. As explained further on, these risks of wrong decision, which we have just mentioned are approximately 10% whenever our actual process standard deviation σ' is near the upper limit of a class, but are a good deal less than 10% when σ' is elsewhere in the interval. They may even be as low as 3%.

In the same manner Table 2 was obtained from Table 2 of Part II.

Both tables also provide classes for the average process range, $\bar{R}$, for the two commonest sample sizes, n, equal to four and five. Thus for such sample sizes it is not necessary to estimate σ' by use of the conventional formula $\sigma' = \bar{R}/d_2$. Instead one merely looks for the class of average ranges for the given sample size 4 or 5, and which contains our actual average range.

As emphasized previously, it is essential that the control chart for ranges (or standard deviations) show good control.

In Tables 1 and 2 as in Parts I and II, whenever an acceptance or rejection number came out like 31.972 (last column Table 2) which would normally be rounded to 32.0, it was rounded instead to 31.9 so as to make it clear that a total of 32 would be regarded as above the rejection number 31.9 and hence that the setting would be rejected. If 32.0 had been recorded, it might not be obvious whether or not to reject.

TWO EXAMPLES

Example 1. The first rough grind for thickness (edge-width) of castings for piston rings shows only one point out of control for sixty samples of five each. The average range is .00059", original measurements being in ten-thousandths of an inch. Specifications are .1380" to .1420". The process standard deviation is $\bar{R}/d_2$, or (5.9 tenths)/2.326, which is 2.5 tenths. Since we can safely let the grinders wear until the process average has risen to a level of $3\sigma'$ below the upper specification, .1420", we regard .14200"—.00075", or .14125" as a criti-

* January, 1949, pp. 12-18 and September, 1949, pp. 15-19.

cal level for $\bar{X}$. Dropping down below this about half of a standard deviation σ', we find .1411" as a convenient "safe" level for the process average σ'. If the process average rises to about one σ' above this, that is, to .1411"+.0025", we would be running at an unsafe level because we would then be closer than $3\sigma'$ to the upper specification .1420". (If greater safety is desired we could use .1410" as the safe level.)

We now set the gage to read zero at .1411". Consulting Table 2 for the one-way check we find that the σ' class, 2.16 to 2.61, includes our σ' of 2.5 (or we could have found our $\bar{R}$ of 5.9 tenths in the class 5.02 to 6.07). The two respective columns in Table 2 give the acceptance and rejection numbers for the algebraic (net) sum of the measurements figured from .1411", and in units of .0001". For the first data shown, (Table A) a decision of "let run" is reached in eight measurements, because at that point our total of +4 is below the "accept" total of 4.7 in Table 2. For the second set of data a decision of "reset" is reached on three measurements since +11 exceeds the "reject" entry, 9.7 for an n of 3 in the proper column of Table 2. Note that none of the three pieces were close to being out of specifications. The decision was "reset," however, because the average level has come too close to .1420" for safety.

Table A

n	Measurements from .1411" in .0001"	Sum
1	−1	−1
2	+1	0
3	−1	−1
4	+4	+3
5	+2	+5
6	−1	+4
7	+1	+5
8	−1	+4

Table B

n	Measurements from .1411" in .0001"	Sum
1	+3	+3
2	+4	+7
3	+4	+11

Example 2. For a piston pin on a centerless grinder operation, the range chart shows only one point out of the control band in 59 samples, although a few more are close. For samples of five, $\bar{R}$ is .000156". Dividing this by $d_2(=2.326)$ gives σ' equal to .000067". Hence, if in control the process can give practically all of its product within ±.00020", about whatever process average is being held. Since specifications are 1.74975"±.00025", the process average must be maintained at a figure close to the nominal in order to avoid out-of-specification pieces.

Accordingly, to check the process average at any time, we set the gage to read zero at 1.74975". Now we use the column in Table 1 in which the class for σ' is 5.63 to 6.81. In order to use the entries in this section we either must measure in one hundred thousandths of an inch, or what is easier, we shift the decimal point for all entries in the Table 1, one place to the left. Thus 23.1 becomes 2.31, etc. Now proceed to measure in ten-thousandths of an inch from 1.74975" as zero. Cumulate the total, taking careful account of the signs. Whenever the total of all the measurements is smaller in size than the "Acc." entry we approve the setting, but if it is larger in size than the "Rej." entry we take appropriate steps to revise the process average. If between, whether the total is plus or minus, we take another piece. Thus in the present example, if the total of six measurements from the nominal is −.5 tenths, −2.0 tenths or −4.5 tenths, the respective decisions would be "approve," "take another measurement," or "reject the setting and take steps to increase the process average." The indicated amount by which to reset in the last case would be 4.5/6 or .75 of a tenth upward.

MATHEMATICAL APPENDIX

The limits for the classes for σ' were set at the consecutive twelfth roots of ten, so as to have a constant percentage increase from the lowest to the highest σ' in each class. The classes for the average range $\bar{R}$ were then obtained by multiplying the class limits for σ' by the d_2 values 2.059 and 2.326 for samples of four and five cases respectively.

When discriminating between two process averages a fixed distance apart, but with a varying σ', it is obvious that the risks of wrong decisions will vary. By equating the fixed distance, d, to the largest σ' in a class, it was thereby assured that the maximum risk at the critical levels would be 10%. The problem of determining the size of the risks which occur when the smallest σ' in the class is used is important.

For the second or one-way choice, the problem is easily solved. Let σ' be the largest standard deviation in the class. Then the smallest is $\sigma'/1.21153$, say σ''. Now for $\alpha = .10$ and $\beta = .10$, we have $\alpha = 2.19722 = b$, and hence, following the usual calculations,*

$$h_1 = b(\sigma')^2/(m_2 - m_1)$$
$$= 2.1972\,(\sigma')^2/\sigma'$$
$$= 2.1972\sigma' = h_2$$

$$s = (m_1 + m_2)/2$$
$$= .5\sigma'$$

if m_1 is taken as zero.

Then the acceptance and rejection numbers for Σx (with m_1 as zero) are

$$[\Sigma x]\text{-Acc.} = -h_1 + sn$$
$$= -2.1972\sigma' + .5\sigma' n.$$
$$[\Sigma x]\text{-Rej.} = +h_2 + sn$$
$$= 2.1972\sigma' + .5\sigma' n$$

But now considering these as the acceptance and rejection numbers of a plan in which $m_2 - m_1 = 1.21153\sigma''$ $(=\sigma')$, $m_1 = 0$, and the standard deviation is σ'', we have

$$-2.1972\sigma' + .5\sigma' n$$
$$= -2.1972(1.21153\sigma'') + .5(1.21153\sigma'')n$$
$$= -2.6620\sigma'' + .60576\sigma'' n$$
$$= -h_1''\sigma'' + s'' n$$

and hence $h_1'' = 2.6620\sigma'' = h_2''$ and $s'' = .60576\sigma''$.

However, we know that

$$h_1'' = b''(\sigma'')^2/(m_2'' - m_1'').$$

Hence

$$2.6620\sigma'' = b''(\sigma'')^2/1.21153\sigma''$$

from which $b'' = 3.2251$, which is also the value of a''. Using the definitions of these quantities, namely

$$a'' = \ln[(1-\beta'')/\alpha''],$$
$$b'' = \ln[(1-\alpha'')/\beta'']$$

we have two simultaneous equations to be solved for α'' and β''. Thus

$$3.2251 = \ln[(1-\beta'')/\alpha'']$$

or

$$(1-\beta'')/\alpha'' = e^{3.2251} = 25.155$$

and

$$(1-\alpha'')/\beta'' = 25.155.$$

Finally,

$$\alpha'' = .0382 = \beta''.$$

Hence when our process standard deviation, σ', is at the lower boundary for any one class we are making a discrimination between two means which are approximately 1.21 times our σ' apart, but our risks are only about 4% for a wrong decision, instead of 10%.

The problem for the two-way decision is more difficult. In fact an exact solution is not available. However, proceeding in the same manner as was just done we can exactly match all of the rejection numbers, and can also match all of the acceptance numbers except where n is so small that the straight line approximation, $-h_1 + ns$, is not applicable. This range is for n

* Statistical Research Group, *Sequential Analysis of Statistical Data: Applications*, Section 4. Columbia University Press, 1945.

TABLE 1 - ACCEPTANCE AND REJECTION NUMBERS FOR CHECKING SETTING TO A DESIRED LEVEL. Protection Against Both Too High And Too Low Settings. Twelve Plans for Various Classes of Process Standard Deviation, σ, and Average Ranges, $\bar{R}$, for Samples of 4 and 5. Range Chart Must be in Control.

Protection Against Proc. Aver. Off by:		1.21		1.46		1.77		2.15		2.61		3.16	
Proc. Std. Dev. σ		1.00-1.21		1.22-1.46		1.47-1.77		1.78-2.15		2.16-2.61		2.62-3.16	
Aver. Range n=5		2.33-2.81		2.82-3.41		3.42-4.13		4.14-5.01		5.02-6.07		6.08-7.35	
Aver. Range n=4		2.06-2.49		2.50-3.02		3.03-3.66		3.67-4.43		4.44-5.37		5.38-6.51	
		Acc.	Rej.	Acc.	Rej.	Acc.	Rej.	Acc.	Rej.	Acc.	Rej.	Acc.	Rej.
Sample Size	1	-	4.1		4.9	-	6.1	-	7.3	-	8.8	-	10.7
	2	-	4.7	-	5.7	-	6.9	-	8.4	-	10.2	-	12.3
	3	-	5.3	-	6.4	-	7.8	-	9.5	-	11.5	-	13.9
	4	-	5.9	-	7.2	-	8.7	-	10.5	-	12.8	-	15.5
	5	.9	6.5	1.2	7.9	1.5	9.6	1.8	11.6	2.1	14.1	2.6	17.1
	6	1.7	7.1	2.1	8.6	2.6	10.5	3.1	12.7	3.8	15.4	4.6	18.6
	7	2.4	7.7	2.9	9.4	3.5	11.4	4.3	13.8	5.2	16.7	6.3	20.2
	8	3.1	8.3	3.7	10.1	4.4	12.3	5.4	14.8	6.5	17.9	7.9	21.8
	9	3.6	8.9	4.4	10.8	5.3	13.1	6.4	15.9	7.8	19.3	9.5	23.4
	10	4.2	9.6	5.1	11.6	6.2	14.1	7.5	16.9	9.1	20.6	11.1	24.9
	11	4.8	10.2	5.9	12.3	7.1	14.9	8.6	18.1	10.4	21.9	12.6	26.5
	12	5.4	10.8	6.6	13.1	7.9	15.8	9.7	19.1	11.7	23.2	14.2	28.1
	13	6.1	11.4	7.3	13.8	8.9	16.7	10.8	20.2	13.1	24.5	15.8	29.7
	14	6.7	11.9	8.1	14.5	9.8	17.6	11.8	21.3	14.3	25.8	17.4	31.3
	15	7.3	12.6	8.8	15.3	10.7	18.5	12.9	22.4	15.7	27.1	18.9	32.9
	16	7.9	13.2	9.5	15.9	11.6	19.4	13.9	23.5	16.9	28.4	20.5	34.4
	17	8.5	13.8	10.3	16.7	12.4	20.3	15.1	24.5	18.3	29.7	22.1	36.1
	18	9.1	14.4	11.1	17.5	13.3	21.1	16.1	25.6	19.6	31.1	23.7	37.6
	19	9.7	15.1	11.7	18.2	14.2	22.1	17.2	26.7	20.9	32.3	25.3	39.2
	20	10.3	15.6	12.5	18.9	15.1	22.9	18.3	27.8	22.2	33.6	26.9	40.8
	21	10.9	16.2	13.2	19.7	15.9	23.8	19.4	28.8	23.5	34.9	28.4	42.3
	22	11.5	16.8	13.9	20.4	16.9	24.7	20.5	29.9	24.8	36.3	30.1	43.9
Prot. Margin		3.83		4.64		5.62		6.81		8.25		10.00	
σ		3.17-3.83		3.84-4.64		4.65-5.62		5.63-6.81		6.82-8.25		8.26-10.00	
$\bar{R}$, n=5		7.36-8.91		8.92-10.8		10.9-13.0		13.1-15.8		15.9-19.1		19.2-23.2	
$\bar{R}$, n=4		6.52-7.88		7.89-9.55		9.56-11.5		11.6-14.0		14.1-16.9		17.0-20.5	
		Acc.	Rej.	Acc.	Rej.	Acc.	Rej.	Acc.	Rej.	Acc.	Rej.	Acc.	Rej.
Sample Size	1	-	12.9	-	15.7	-	19.1	-	23.1	-	27.9	-	33.9
	2	-	14.9	-	18.1	-	21.9	-	26.5	-	32.1	-	38.9
	3	-	16.8	-	20.4	-	24.7	-	29.9	-	36.2	-	43.9
	4	-	18.7	-	22.7	-	27.5	-	33.3	-	40.4	-	48.9
	5	3.1	20.7	3.8	25.1	4.6	30.3	5.6	36.7	6.8	44.5	8.2	53.9
	6	5.5	22.6	6.7	27.3	8.1	33.1	9.8	40.1	11.9	48.6	14.4	58.9
	7	7.6	24.5	9.2	29.7	11.1	35.9	13.5	43.5	16.3	52.7	19.8	63.9
	8	9.5	26.4	11.6	31.9	13.9	38.7	16.9	46.9	20.5	56.9	24.9	68.9
	9	11.5	28.3	13.9	34.3	16.8	41.6	20.4	50.4	24.7	61.1	29.9	73.9
	10	13.4	30.2	16.2	36.6	19.7	44.4	23.8	53.8	28.8	65.1	34.9	78.9
	11	15.3	32.1	18.5	38.9	22.5	47.2	27.2	57.2	32.9	69.3	39.9	83.9
	12	17.2	34.1	20.9	41.3	25.3	49.9	30.6	60.6	37.1	73.4	44.9	88.9
	13	19.1	35.9	23.2	43.6	28.1	52.8	34.1	63.9	41.2	77.5	49.9	93.9
	14	21.1	37.9	25.5	45.9	30.9	55.6	37.4	67.4	45.4	81.6	54.9	98.9
	15	22.9	39.8	27.8	48.2	33.7	58.4	40.8	70.8	49.5	85.8	59.9	103.9
	16	24.9	41.7	30.2	50.5	36.5	61.2	44.3	74.2	53.6	89.9	64.9	108.9
	17	26.8	43.6	32.5	52.9	39.3	64.1	47.7	77.6	57.7	94.1	69.9	113.9
	18	28.7	45.6	34.8	55.2	42.2	66.9	51.1	81.1	61.9	98.1	74.9	118.9
	19	30.6	47.5	37.1	57.5	44.9	69.7	54.5	84.4	65.9	102.3	79.9	123.9
	20	32.6	49.4	39.4	59.8	47.8	72.5	57.9	87.8	70.1	106.4	84.9	128.9
	21	34.5	51.3	41.8	62.2	50.6	75.3	61.3	91.2	74.3	110.5	89.9	133.9
	22	36.4	53.2	44.1	64.5	53.4	78.1	64.7	94.6	78.4	114.7	94.9	138.9

TABLE 2 - ACCEPTANCE AND REJECTION NUMBERS FOR CHECKING SETTING TO A DESIRED LEVEL OR BELOW. Protection Against Too High a Setting. Twelve Plans for Various Classes of Process Standard Deviation, σ', and Average Ranges, $\bar{R}$, for Samples of 4 and 5. Range Chart Must Be in Control. (Same constants useful if checking against too low a setting. In such a case set zero at dangerously low $\bar{X}$ and interchange the headings "Acc." and "Rej." in table below.)

Protection Against Proc. Aver. High by:		1.21		1.46		1.77		2.15		2.61		3.16	
Proc. Std. Dev. σ'		1.00-1.21		1.22-1.46		1.47-1.77		1.78-2.15		2.16-2.61		2.62-3.16	
Aver. Range n=5		2.33-2.81		2.82-3.41		3.42-4.13		4.14-5.01		5.02-6.07		6.08-7.35	
Aver. Range n=4		2.06-2.49		2.50-3.02		3.03-3.66		3.67-4.43		4.44-5.37		5.38-6.51	
		Acc.	Rej.	Acc.	Rej.	Acc.	Rej.	Acc.	Rej.	Acc.	Rej.	Acc.	Rej.
Sample Size	1	-2.1	+3.3	-2.5	+3.9	-3.1	+4.8	-3.7	+5.8	-4.4	+7.1	-5.4	+8.5
	2	-1.5	3.9	-1.8	4.7	-2.1	5.7	-2.6	6.9	-3.1	8.3	-3.8	10.1
	3	- .8	4.5	-1.1	5.4	-1.2	6.6	-1.5	7.9	-1.8	9.7	-2.2	11.7
	4	- .2	5.1	- .3	6.2	- .4	7.5	- .4	9.1	- .5	10.9	- .6	13.3
	5	+ .4	5.7	+ .4	6.9	+ .5	8.4	+ .7	10.1	+ .8	12.3	+ .9	14.9
	6	.9	6.3	1.2	7.6	1.4	9.2	1.7	11.2	2.1	13.6	2.5	16.4
	7	1.6	6.9	1.9	8.4	2.3	10.1	2.8	12.3	3.4	14.9	4.1	18.1
	8	2.2	7.5	2.6	9.1	3.2	11.1	3.9	13.4	4.7	16.2	5.7	19.6
	9	2.8	8.1	3.4	9.8	4.1	11.9	4.9	14.4	6.1	17.5	7.3	21.2
	10	3.4	8.7	4.1	10.6	4.9	12.8	6.1	15.5	7.3	18.8	8.9	22.8
	11	4.1	9.3	4.8	11.3	5.9	13.7	7.1	16.6	8.6	20.1	10.4	24.3
	12	4.6	9.9	5.6	12.1	6.8	14.6	8.2	17.7	9.9	21.4	12.1	25.9
	13	5.2	10.5	6.3	12.8	7.7	15.5	9.3	18.7	11.2	22.7	13.6	27.5
	14	5.8	11.1	7.1	13.5	8.5	16.4	10.3	19.8	12.5	24.1	15.2	29.1
	15	6.4	11.7	7.8	14.2	9.4	17.2	11.4	20.9	13.8	25.3	16.8	30.7

Prot. Margin		3.83		4.64		5.62		6.81		8.25		10.00	
σ'		3.17-3.83		3.84-4.64		4.65-5.62		5.63-6.81		6.82-8.25		8.26-10.00	
$\bar{R}$, n=5		7.36-8.91		8.92-10.8		10.9-13.0		13.1-15.8		15.9-19.1		19.2-23.2	
$\bar{R}$, n=4		6.52-7.88		7.89-9.55		9.56-11.5		11.6-14.0		14.1-16.9		17.0-20.5	
		Acc.	Rej.	Acc.	Rej.	Acc.	Rej.	Acc.	Rej.	Acc.	Rej.	Acc.	Rej.
Sample Size	1	-6.5	+10.3	-7.9	+12.5	-9.5	+15.2	-11.6	+18.4	-14.1	+22.3	-16.9	+26.9
	2	-4.6	12.2	-5.6	14.8	-6.7	17.9	- 8.2	21.8	- 9.9	26.4	-11.9	31.9
	3	-2.7	14.2	-3.2	17.2	-3.9	20.8	- 4.8	25.2	- 5.8	30.5	- 6.9	36.9
	4	- .8	16.1	- .9	19.5	-1.1	23.6	- 1.3	28.6	- 1.6	34.6	- 1.9	41.9
	5	+1.2	17.9	+1.4	21.8	+1.7	26.4	+ 2.1	32.1	+ 2.5	38.8	+ 3.1	46.9
	6	3.1	19.9	3.7	24.1	4.5	29.2	5.5	35.4	6.6	42.9	8.1	51.9
	7	4.9	21.8	6.1	26.4	7.3	32.1	8.9	38.8	10.8	47.1	13.1	56.9
	8	6.9	23.7	8.4	28.8	10.1	34.8	12.3	42.2	14.9	51.2	18.1	61.9
	9	8.8	25.7	10.7	31.1	12.9	37.7	15.7	45.6	19.1	55.3	23.1	66.9
	10	10.7	27.6	13.1	33.4	15.8	40.5	19.1	49.1	23.1	59.4	28.1	71.9
	11	12.7	29.5	15.3	35.7	18.6	43.3	22.5	52.4	27.3	63.5	33.1	76.9
	12	14.6	31.4	17.7	38.1	21.4	46.1	25.9	55.8	31.4	67.7	38.1	81.9
	13	16.5	33.3	19.9	40.4	24.2	48.9	29.3	59.3	35.5	71.8	43.1	86.9
	14	18.4	35.2	22.3	42.7	27.1	51.7	32.7	62.7	39.6	75.9	48.1	91.9
	15	20.3	37.2	24.6	45.1	29.8	54.5	36.1	66.1	43.8	80.1	53.1	96.9

equal to 5 and 6 only. Hence we have practically duplicated the sampling plan, but have not exactly done so. The plan $m_1=0$, $d=1.21153\sigma''$, $\alpha''=.027261$ and $\beta''=.053481$ provides $a''=3.5473$, $b''=2.9008$.

Then

$$h_1''=(\sigma'')^2(b''-.69315)/d''$$
$$=(\sigma'')^2(2.9008-.69315)/1.21153\sigma''$$
$$=[(\sigma')^2/(1.21153)^2](2.20765)/\sigma'$$
$$=1.504\sigma'$$

and similarly

$$h_2''=(\sigma'')^2(a''+.69315)/d''$$
$$=2.889\sigma'$$

and

$$s''=1.21153\sigma''/2=\sigma'/2.$$

Since these are respectively the h_1, h_2 and s, the acceptance and rejection numbers are the same for all sample sizes n for which the graph is a straight line (but not in the curved part for the acceptance numbers). We can therefore say that the risk of reaching a decision to "reset" when the setting is already perfect is somewhere between .03 and .10, while that for failing to reset when the process average is the indicated amount, d, too high or too low, is somewhere between .05 and .10.

MEMBERSHIP

J. R. STEEN

Chairman,
Committee on Membership

Beginning with this issue of Industrial Quality Control and continuing for the next several issues, charts will be published indicating progress made by the various Sections in securing paid memberships for 1949-1950. Although this first chart shows only the total number of paid memberships to and including September 30, it is expected that future charts will cover progress at 60-day intervals as well.

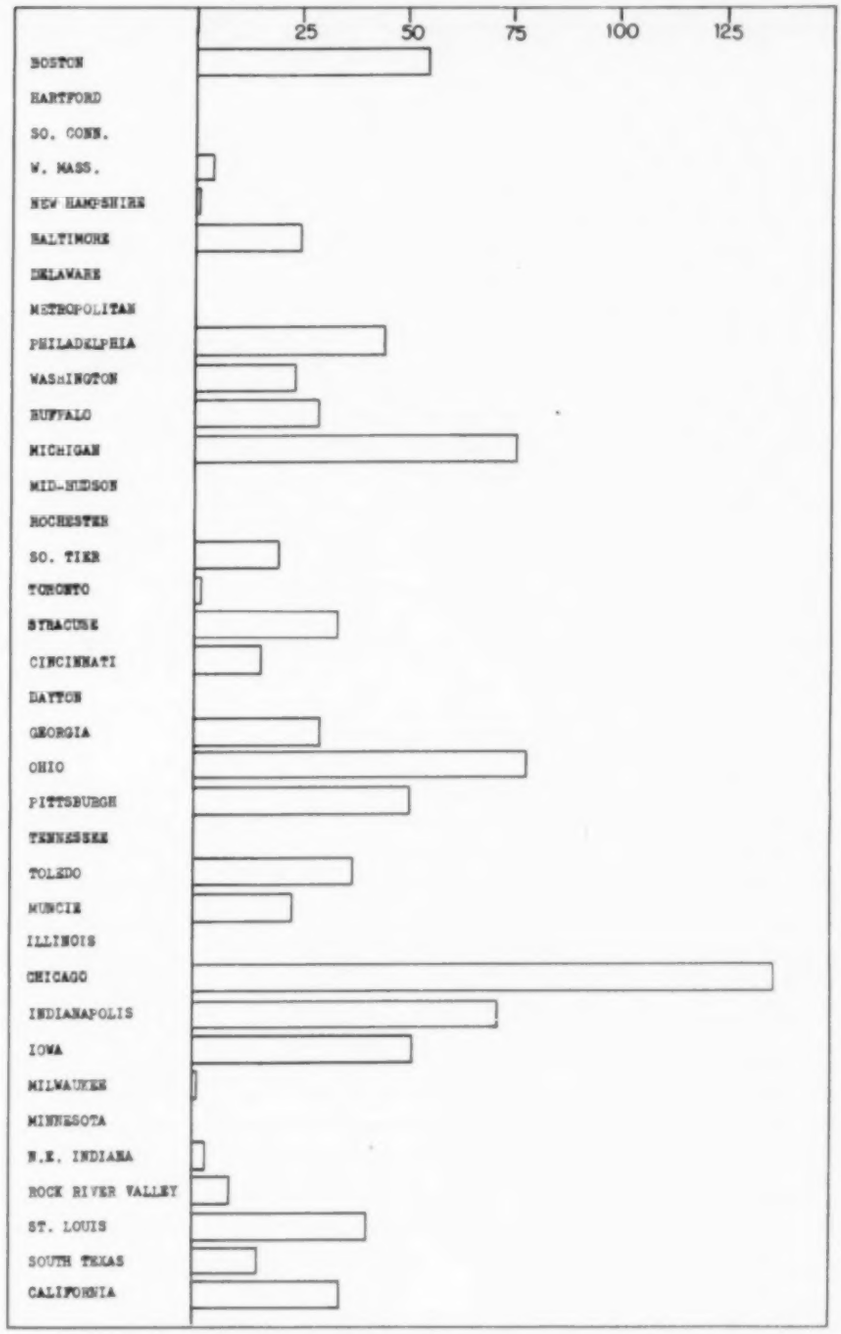
Let's take a look at the current chart. What do we see? First, Chicago has 137 paid members as compared with 170 for all of last year. An excellent record indeed! Ohio has 78 paid memberships, Michigan 76, Indianapolis 72 and Boston 60. Several others have approximately 25 paid memberships and several others (10 to to be exact) have none. There are 163 members at large and 8 members in training. When it is realized that the membership year is one-fourth over, this is *not* an enviable record, taken as a whole.

Now let's see how our figures compare with those of last year. On September 15, 1949 there were 783 paid memberships as compared with 520 on September 15, 1948. Encouraging indeed, but due to the extra activities of a very few Sections. No figure is available for September 30, 1948 to compare with the total of 1,092 paid memberships as of September 30th this year.

Based on a total of 2,639 memberships for the year 1948-1949 and a goal of 3,500 memberships by June 30, 1950, we are just about holding our own. The percentage of the total as of September 15th a year ago was approximately 20 percent as compared with approximately 22 percent this year. This fails to take into account, however, the fact that five new Sections have been added in the meantime.

One particularly fruitful area from which new ASQC members can be recruited is the local society organization. Not long ago at one local meeting membership figures were given as about 250. This is roughly twice the number of ASQC members reported by this Section at the end of the 1948-1949 season. Efforts expended along this line, as well as in promoting the general upgrading of members, will go far in strengthening our Society to the point where it can weather any storm.

BAR-CHART OF PAID-UP ASQC MEMBERS PER SECTION AS OF SEPTEMBER 30, 1949



NOTICE

The Constitution of the Society, Section 23d, specifies that members whose national dues have not been received by January 1 become delinquent in this respect, and thus their names must be removed from the mailing list for the receipt of Industrial Quality Control and its News Supplement. Members are asked to cooperate by paying their 1949-50 dues immediately, so as to be sure of receiving all Society publications.

Simon Collier

Executive Secretary

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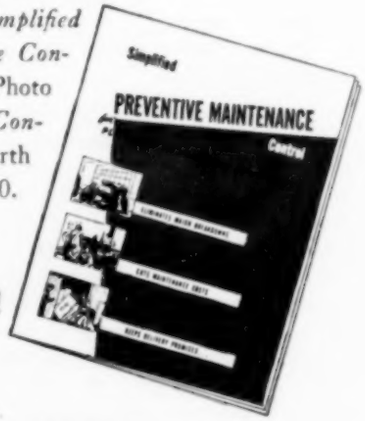

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THE FIRST NAME IN BUSINESS SYSTEMS

Quality is a Management Responsibility*

E. FINLEY CARTER

VICE PRESIDENT IN CHARGE OF ENGINEERING, SYLVANIA ELECTRIC PRODUCTS, INC.

THE QUALITY ATTITUDE

Quality is an ideal. It is an attitude that must originate at the very top of an organization and be a vital part of a corporation's personality. There should be no doubt about this. It should need no elaboration. Unfortunately, however, so many pressing problems are facing management today that there is too often a temptation to become overly involved in putting out fires with the result that too little basic thought is given to preventing the fires in the first place. Then, too, there are some who, having established a Quality Department—which too often means an Inspection rather than a Quality Control Department—lull themselves into a false sense of security by saying "Quality is their responsibility," without realizing the importance of management attitude and support.

At the risk of stating much that is or should be obvious, let us analyze the statement "Quality is a Management Responsibility." The statement, "By their fruits you shall know them. Do men gather grapes of thorns or figs of thistles?" might well be paraphrased to say, "Quality of products reflect management. Does reliability sprout from irresponsibility, or uniformity from carelessness?"

To insure a product of high quality, we must first have high quality leadership on the part of management—leadership born of integrity, and a sincere interest in the ultimate consumer. Back of this is our practical belief that real profits can be assured only by serving well the consumer's interest. Strong convictions and courage to support the quality ideal are required. Patience in the face of criticism and tolerance of the other fellow's point of view, coupled with vision and perseverance, a keen interest in human relations, and the ability to select and inspire men who will want to execute a sound management philosophy are attributes that go to make up this kind of leadership.

This ideal, of course, is seldom, if ever, fully achieved. Neither is perfection. But where it is approached, there are many outward manifestations that show up on a check list of such a management. Good housekeeping is evident in plant and office. Sound engineering principles are applied in the development and design of the organization's products. Materials and tolerances are well defined. Specifications are thorough and complete. Organization personnel is well selected, properly trained, interested in and happy with its work and environment.

Where these conditions prevail, the very atmosphere in a plant inspires good workmanship. A well laid out, well lighted and immaculately clean plant makes that which is disorderly an exception rather than the rule, and thus focuses attention upon it until it is corrected. Individuals who work in such an environment are more particular about their personal appearance and their work. The results are a better product—a satisfied customer—a prosperous business. Good quality is regenerative; poor quality degenerative.

IMPLEMENTING THE QUALITY ATTITUDE

I have discussed philosophy or attitude first because I believe it is the essential ingredient. However, do not let me leave the impression that there is no need for implementation. Modern aviation required first the desire to fly, plus the faith that it was possible, and the perseverance to see that it came about; but the science of aeronautics had to be learned and applied to get the modern airplane. The war accelerated the development and application of a scientific approach to Quality Control. There is much to be learned that will extend and make more effective the basic principles now being applied. The application of this knowledge will in itself extend its usefulness as well as its effectiveness. We are rapidly learning that it is necessary to build quality into a product. It does not suffice merely to inspect defects out after the product has been made.

One incident that particularly stands out in my memory was my initial interview with Mr. Walter E. Poor, then Vice President in Charge of Engineering and Manufacturing of Hygrade Sylvania, now Chairman of Sylvania's Board of Directors. It was a pleasant conversation in which I got a glimpse of the philosophy whose application has had much to do with Sylvania's success. It impressed me to hear a responsible business man take the stand that lamp and tube life should be increased way beyond what was generally accepted as satisfactory. His conviction was based upon giving "good measure, heaped up and running over" but he was practical enough to know that even though longer life may mean fewer total lamps and tubes sold, it did not necessarily mean lower sales of the high quality brands.

It did not take me long to become convinced that Hygrade Sylvania was the company with which I wanted to become associated and through that association the opportunity has been afforded to witness the practical applications of the ideals expressed in that conversation over fifteen years ago.

Some of the fine points of statistical Quality Control, as we know it now, had not been developed or applied then. If they had been known and ap-

* Presented before a joint meeting of the American Society for Quality Control and the Society for the Advancement of Management, January 22, 1948.

preciated, they would have been put to work, for the desire to build quality into the product rather than to inspect defects out was present. Mr. Poor's philosophy was not always accepted by everyone. There was some severe opposition when he instituted a "no repair policy." It was hard for a cost-minded production man to throw away an otherwise good tube which had been rejected for "poor solder" when a brief redipping into a soldering pot would make it pass specifications. But Mr. Poor could see beyond the immediate day's cost. He was convinced that if such drastic consequences were the result of careless soldering, something would be done about it. Careless soldering would be eliminated—and it was!

Sylvania's management and personnel have placed great emphasis upon the importance of good housekeeping. A Plant Manager who does not keep his time clocks accurate or his wash rooms immaculately clean or who neglects other seemingly small details is not likely to have a good quality record. These criteria have been used well by both Mr. Walter Poor and Mr. Frank Poor, the founder of the Hygrade Lamp Company, from which the New England branch of Sylvania grew. They were also exemplified by the management of the Pennsylvania Branch of the company.

Though lacking the present-day knowledge of statistical Quality Control, Hygrade Sylvania and later Sylvania put much weight upon the results of sampling tests. Inspection and testing of the finished product commanded a great deal of attention. This alone, however, was not considered adequate. Though a wide range of characteristics were checked, data that may have been statistically helpful were not derived from production tests. Separate Quality Departments under Engineering supervision recorded data from quality check measurements and life tests results. These data served as guides for setting of specification limits and as criteria for justifying the release or hold-up of the production they represented, but full application of statistical principles of Quality Control was to come later. Thus Sylvania was ready organically and had the facilities to put to work more knowledge of Quality Control as it developed.

In each plant of Sylvania, there is a Supervisor of Quality Control directly responsible to the Plant Manager. He is functionally responsible to the Manager of Quality Control who is on the Staff of the General Manager of the Division. The Division Manager of Quality Control is, in turn, functionally responsible to the Director of Quality Control who reports to the President through the Vice President in Charge of Engineering. Thus in Sylvania, quality of product is not only a direct responsibility of the Plant Managers, but there are functional lines directly to the General Manager of the Division and to the President himself to insure that quality is truly a responsibility of management.

During the war, the statistical method of Quality Control, as a pattern for wartime production, was being stressed. To many people, the art of good Industrial Relations as well as the art of Quality Control, as we know it today, was new. From the wartime schools for training in the basic statistical methods have come revolutionary but mature Quality Control techniques for post-war production.

At that time, the statistical method was an emergency expedient to assure quality production by prime and subcontractors dependent on each other. At the same time Industrial Relations techniques were stressed to integrate human efforts to assure adequate production at adequate quality levels.

Improved human relations from top management to the worker at the bench were found essential parts of any quality program. Good relations, it was discovered, must be present at the outset if the basic statistical method of Quality Control is to be put across effectively. It must be accepted, and let us remember that workers are often suspect of a new administrative interest in their tasks.

This was important then, when the first order of business was production and more production. Also important then was the education of management in the new method, an appreciation of the laws of probability versus the older inspection methods of checking product. I say it was important then because it held the key to better postwar production.

Today, with management aware of the importance of Quality Control, and administrative staffs built for far more effective and extended application than could have been imagined seven years ago, Quality Control is truly a management responsibility.

THE VALUE TO MANAGEMENT OF MODERN QUALITY CONTROL

One way of serving better, today, is to maintain and improve quality in a market where the quality average has declined. The maintenance of quality, now possible on an engineering basis, thanks to Quality Control, is not an expense.

Rather it is a form of profitable insurance. Responsibility for showing management the "policy" is the task of the Quality Control engineer. Responsibility for the adoption of the "policy" is management's.

Together, management and the Quality Control engineer can do much to assure present profitable production and secure customers in a buyers' market. Better quality stimulates worker pride and morale. It also helps safeguard him against layoffs when product demand wanes—and someday we are going to have to *sell* automobiles, clothing, and perhaps even food, again.

The value of product quality to a business is greater today than at any time in a generation. The mass of people have money. The mass of people want the best. Having suffered, and to an increasing rather than a decreasing degree in recent years, from shoddy quality, people are beginning to make comparisons again. Those comparisons can be the bricks that build a firm foundation for tomorrow's business.

Quality Control is also a management responsibility because it provides a vital answer to the problem of higher labor costs. Shrinkage can be controlled and kept out of the finished product without violation of any labor law, to protect management and the customer from the taints of worker misunderstanding.

Management that appreciates the modern Quality Control method has learned that it is both a check and an economy in times of labor unrest and high wages. Therefore, it is a practical means of fighting inflation. Through the reduction of shrinkage, high direct labor loss is saved, expensive raw material is utilized to the utmost and overall product quality is raised.

Properly presented to the worker, through apt human relations, it increases rather than lessens appreciation for his labors. He has a better chance of making his work show by the reduction of rejects, thereby an opportunity to derive satisfaction from his work.

This is important. The product made grudgingly by the worker who derives from it only the monetary reward which he considers inadequate is often bought by a customer who feels cheated because of inferior workmanship, quality or performance. In contrast, a product made by the worker who puts himself and his interests into it, thereby deriving not only monetary compensation, but the satisfaction of a job well done, usually receives the commendation of the customer who derives great satisfaction from telling others of his purchase. Real value can be measured best by the satisfaction gained from the service rendered. A corollary to this: the management that is able to instill such an attitude into the minds and hearts of its organization personnel is likely to count its profits in significant dollar figures, whereas the one which does not, finds failure, or at best only mediocre success.

SQC in the Manufacture of Piston Rings*

CARL E. HOOVER

QUALITY CONTROL ENGINEER, PERFECT CIRCLE CORPORATION

MAKING A PISTON RING

Let's take a quick look at the processes which bring a Piston Ring into being. Impressions of a ring pattern are made in sand, these molds are placed one on top of the other 15 to 20 molds high. Hot iron is poured into the top of the stack and flows into the impressions in the sand, forming castings. After cooling, the tree of castings is lifted out of the flasks and the sand is shaken off. Rings are stripped from the tree into a barrel and taken to tumbling mills to be cleaned. The castings are then inspected and ground, and sent out to the machining plants.

At the machining plants the first operation is grinding the edgewidth to finish dimension. The next operation form-turns the outside diameter and mills the gap in the rings. From here the rings go to the boring operation which machines the inside diameter. The grooving operation then channels and slots the face of the rings, after which finish-turning puts the final contour on the ring's face. The final operation is broach or sizing the end clearance or gap dimension in the ring. Rings are then oiled and rolled and placed in the warehouse to be checked out against orders for manufacturers and replacement; packaged and shipped.

SQC BEGINS AT PERFECT CIRCLE

Five or six years ago a foreman was taken off the production line and turned over to the Chief Engineer to do research work on ring castings. Later, he was given to the Director of Market Research and taught the fundamentals of statistics and their application. In 1944, he was sent to the intensive course in Quality Control given at Purdue University under O.P.R.D. Upon returning he was placed on the Central Staff in the Industrial Engineering Department.

The first job investigated was grinding. It was found that the machines could be "navigated" with a control chart. In other words, the charter could tell the operator which way to adjust and how much, thereby keeping the product running right down the middle of the specification. Further checking showed that operators were making decisions on the basis of the measurement of one ring. Two times out of three, the wrong decision was being made, and about half the time adjustments were being made in the wrong direction. All operators were riding the high limit.

The initial step toward correcting the existing condition was to insist that operators shoot at the mean dimension; in addition, each operator was provided with a Sheffield Gauge and instructed to set it up with zero as the mean dimension. Operators could not find the middle of the limit. More investigation revealed the reason. Rings ran out of the machines on to stakes at a rate of 300 to 400 per minute. The stakes of rings were placed neatly in rows in pans. Between stakes the operator might adjust the machine with the result that he had a pan of rings with each row at a different level. Consequently, at the next pass, the operator was, in effect, chasing the level of the rows in the pan. By removing the stakes and running the rings loose in large boxes, the product was homogenized so that the operator could set up his machine to remove the required amount of stock and let it (machine) worry about taking the variation out of the rings. This, along with basing decisions on the measurement of five rings instead of one, plus shooting at the mean dimension, resulted in the disappearance of rework. The disturbing factor was a sudden jump in undersize rings. Further investigation showed that all of the rings that were on the low limit at the finish grinding operation were undersize at inspection. Specifications were the same at both locations. Because of a washing operation, and because the rings cooled between the finish grinding operation and inspection, there was a .00005" level drop. By raising the finish grind mean .00005", the edgewidth characteristic came in on the proper beam. It was a combination of all these things that brought the grinding process under control.

Before control the grinding cost was	$1.52 per/m
After control the grinding cost is	.31 per/m
Saving	1.21 per/m
Before control	28 Inspectors
After control	2 Inspectors
Before control scrap level was	3.82%
After control scrap level was	.42%

Scrap at this location worth $1000 for each percentage point per month.

* Presented at the Third Midwest Quality Control Conference, Chicago, Ill., November 4, 1948.

FURTHER APPLICATIONS OF SQC

The work done in grinding brought simultaneous requests for investigation from many quarters. Necessity seemed to dictate the following approach. In each plant an Outgoing Quality Inspector began measuring and recording the critical characteristics on a cross section of rings going out of each plant daily. The checks were made after all machining and inspection operations had been completed. In other words, the product as it looks going into the field.

Each week these data go into a central office where they are analyzed, and a picture story goes up to top management no later than Wednesday following the week portrayed.

This Quality Audit enables Managers, Production men, Inspectors, and other interested persons, to see not only what their plant is doing with regard to critical characteristics, but to see also how they compare with their sister plants and the kind of material being supplied to all plants from the common source, the foundry. This lessens the natural tendency to buck passing.

The realization that the weekly pictures would change only by chance, unless something was done at the source, started people working at their own problems. The foundry began using statistical methods in the sand laboratory, metallurgical laboratory, in charging, melting, molding, grinding, and inspection. Verification operators began checking packaging. A dimensional control department was organized in October 1947, which saved over $100,000 in four months in one plant alone.

A permanent Inventory Investigator checking and correcting errors, assigning error responsibility to specific individuals, gives definite indication that Auditors will now take year-end inventory from the book records, thus eliminating the necessity of shutting down for a physical inventory.

A Customer Quality Audit by part number goes into the hands of Sales Engineering where it is turned over to the engineer responsible for that particular account.

SUMMARY

The manufacturing problem then, is not one of making a piece. Rather, it is the problem of making hundreds, thousands, even millions of pieces whose quality characteristics will distribute themselves uniformly around the centers of the dimensions specified.

Modern Quality Control is a set of statistical tools with which one is able to go to a machine or process and ask what it is doing with respect to the quality characteristic it is contributing. These techniques will tell not only what the process is doing, but what it is capable of doing, and, if a fault exists, they frequently help to assign the responsibility for that fault to the process, the machine, or the operator.

A Note on Truncated Distributions

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In the paper "Tolerances—Additive or Pythagorean?" by F. S. Acton and E. G. Olds, *Industrial Quality Control* Nov. 1948, the authors find it necessary to compute the standard deviation, σ_c, of the truncated normal distribution where $(\sigma_c)^2$ is defined as

$$(1) \qquad (\sigma_c)^2 = \frac{\int_{k_1}^{k_2} u^2 f(u)du}{\int_{k_1}^{k_2} f(u)du} - \left[\frac{\int_{k_1}^{k_2} uf(u)du}{\int_{k_1}^{k_2} f(u)du}\right]^2$$

with

$$f(u) = \frac{1}{\sqrt{2\pi}} e^{-u^2/2}.$$

The denominators of the above fractions are readily evaluated from an ordinary table of areas of the normal distribution. In order to evaluate the numerators, Table IX of Karl Pearson's "Tables for Statisticians and Biometricians," Vol. I, a volume which is not generally available, is employed.

It is desired to point out that when the Pearson tables are not available, the following formulas, which require only an ordinary table of areas and ordinates of the normal distribution, may be used:

$$(2) \qquad (\sigma_c)^2 = \left[1 + \frac{k_1 f(k_1) - k_2 f(k_2)}{\int_{k_1}^{k_2} f(u)du}\right] - \left[\frac{f(k_1) - f(k_2)}{\int_{k_1}^{k_2} f(u)du}\right]^2$$

where $f(k_1)$ is the ordinate of the normal distribution at the point of truncation, k_1, and $f(k_2)$ is the ordinate at the second truncation point, k_2. Otherwise the notation is the same as that used in the original paper.

For a symmetric truncation at distances of $\pm k\sigma$ from the mean this result becomes

$$(3) \qquad (\sigma_c)^2 = 1 - \frac{kf(k)}{\int_0^k f(u)du}.$$

Anyone interested can easily verify the fact that the above formulas give the same numerical results as those obtained by Acton and Olds for the illustrative examples in their paper. These results were derived by expressing the various integrals of Equation (1) in terms of the I_n functions of R. A. Fisher which are discussed by him in "Properties and Applications of Hh Functions," Introduction to the British Association Mathematical Tables, Vol. 1, 1931 pp. xxvi--xxxv.

Nomograph for Determination of Variables Inspection Plans for Fraction Defective

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A common method of specifying the desired consequences of a sampling plan for destructive or non-destructive test characteristics involves the selection of:

1. A desirably low value of fraction defective p_1.
2. A probability or risk, α, of rejecting a lot from a process of p_1 quality (or a lot of p_1 quality).
3. An undesirably high value of fraction defective p_2.
4. A probability or risk, β, of accepting a lot from a process of p_2 quality (or a lot of p_2 quality).†

For all practical purposes these four constants uniquely determine the sample size n and acceptance number c of a single sampling plan for attributes. For example: if $p_1 = .005$ and the risk of rejecting quality p_1 is $\alpha = .02$, $p_2 = .05$ and the risk of accepting quality p_2 is $\beta = .10$, then the n and c that most nearly satisfy these conditions are respectively 110 and 2. A simple graphical method for finding the parameters of such plans from the Poisson Cumulative Probability Chart is available. (Ref. 4)

If the quality characteristic under consideration can be measured on a continuous scale, that is, if it is a variable, each unit tested can be classed or described by the numerical value observed. A defective unit is one whose value is less than some specified minimum limit or more than some specified maximum limit. It has been pointed out (Ref. 2, 5) that the methods of acceptance sampling by variables are to a considerable degree a direct extension of those used in the attributes case. If the quality characteristic under consideration is normally distributed, its fraction defective with respect to a given limit can be completely determined from

$$t_p = (\bar{X}' - L)/\sigma'$$

where

$\bar{X}'$ = mean of material sampled,
σ' = standard deviation of material sampled,
L = specified limit,
t_p = normal deviate corresponding to fraction defective, p.

In a sample of size n, however, we can only estimate $\bar{X}'$, σ' and the fraction defective of the material sampled by using the sample estimates of the lot average $\bar{X}$ and s, where using $\bar{X} = (\Sigma x)/n$ and $s = \sqrt{\Sigma(x - \bar{x})^2/(n-1)}$. The acceptance criterion and sample size can be so adjusted that the magnitude of the risk of making incorrect decisions due to sampling errors is fixed. Specifically, the risk of rejecting quality p_1 and the risk of accepting quality p_2 may be defined. The design of a variables sampling plan based on precisely the same four constants or conditions enumerated previously for the attributes illustration is possible.

Such single sampling plans for variables may be calculated (Ref. 3) from

$$(1)\quad t_A = (k - t_p)/\sqrt{1/n + k^2/2(n-1)}$$

where

t_A = normal deviate exceeded by the probability of acceptance, P_A. t_A is positive for values of P_A smaller than .50 and is negative for values of P_A larger than .50.

t_p = normal deviate exceeded by the probability, p. p = fraction defective, to which P_A, the probability of acceptance, applies. t_p is positive for values of p less than .50.

n = sample size

k = coefficient of the sample estimate of lot standard deviation, s, in the acceptance criterion.

$$\bar{X} \geq L_{min.} + ks$$

or

$$\bar{X} \leq L_{max} - ks$$

with

$\bar{X}$ = sample mean,
$L_{min.}$ = specified minimum limit
$L_{max.}$ = specified maximum limit.

If we substitute, for the conditions cited previously for the attributes problem:

$t_p = 2.576$ (from normal law tables: deviate corresponding to $p_1 = .005$),
$t_A = -2.054$ (corresponding to $\alpha = .02$)

in equation (1), we have an equation with two remaining unknowns, n and k. If we substitute

$t_p = 1.645$ (corresponding to $p_2 = .05$),
$t_A = 1.282$ (corresponding to $\beta = .10$),

then a second equation is obtained with n and k as unknown. The simultaneous solution of these equations will yield $n = 39$, $k = 2.00$ (compare with $n = 110$ obtained previously for attributes).

These plans are applied in practice where the $\bar{X}'$ and σ' of the material sampled are unknown and it is necessary to judge acceptability from the sample estimate of average and standard deviation, $\bar{X}$ and s. This type of plan is, of course, quite similar to the attributes type of plan where the acceptance number c is replaced by the acceptance criterion $\bar{X} \geq L_{min.} + ks$, or $\bar{X} \leq L_{max} - ks$. It is applicable where variables data are obtainable and

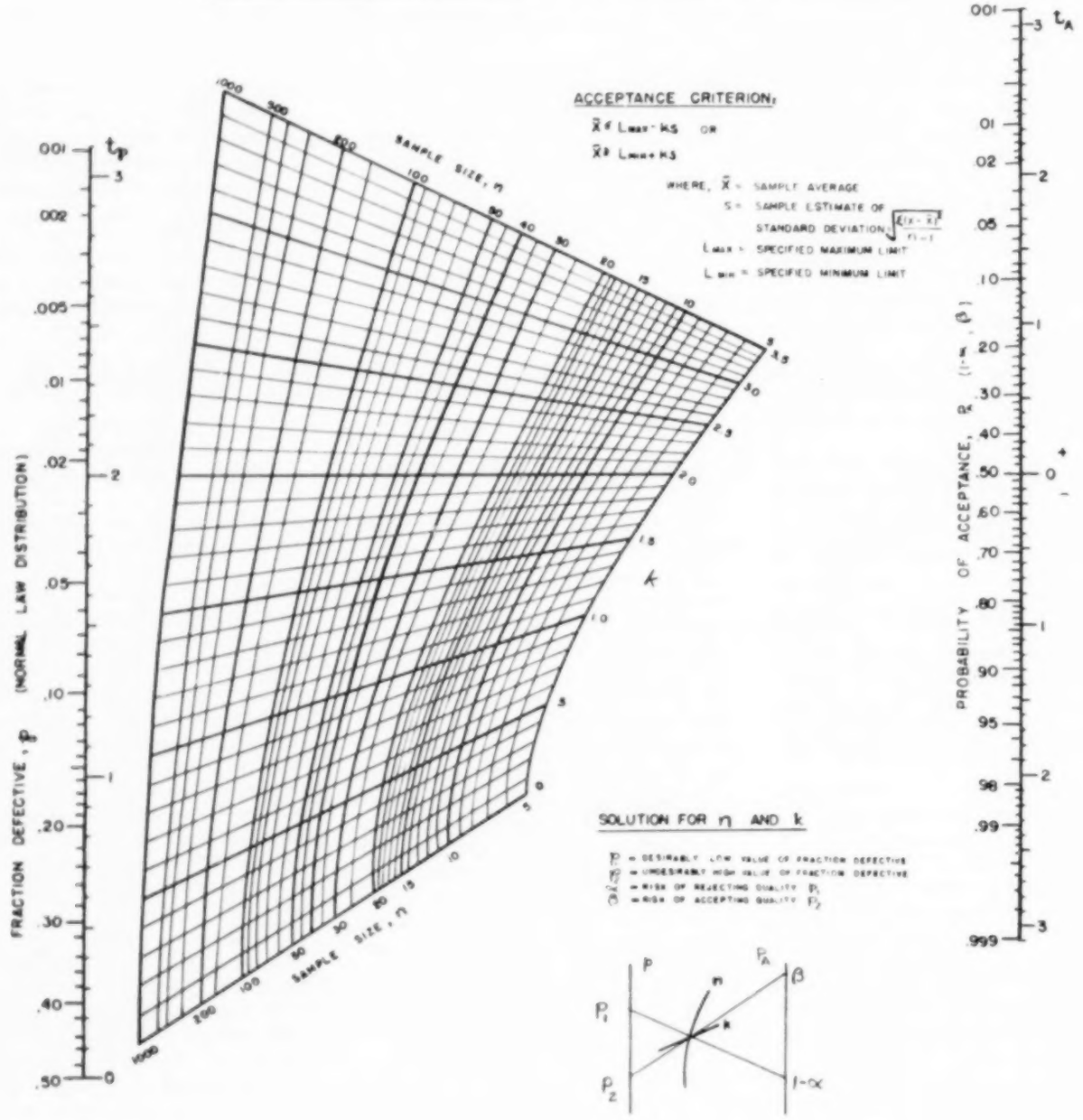
† See References 1, 2 and 3 for development of attributes and variables plans based on these and other conditions. So long as the sample size n is a small percentage (say under 10%) of the lot size, we may for all practical purposes speak interchangeably of a lot or of a process of p quality; the effect of lot size can be neglected. This condition is assumed in this paper.

* Mr. Jacobson is now Supervisor of the Quality Control Department at International Resistance Company in Philadelphia, Pa.

NOMOGRAPH FOR DETERMINATION OF VARIABLES INSPECTION PLANS FOR FRACTION DEFECTIVE

– MEAN AND STANDARD DEVIATION OF MATERIAL SAMPLED UNKNOWN –

$$\left[t_A = \frac{k - t_p}{\sqrt{\frac{1}{n} + \frac{k^2}{2(n-1)}}} \right]$$


ACCEPTANCE CRITERION:
$\bar{X} \leq L_{max} - kS$ OR
$\bar{X} \geq L_{min} + kS$
WHERE, $\bar{X}$ = SAMPLE AVERAGE
S = SAMPLE ESTIMATE OF STANDARD DEVIATION $\sqrt{\frac{\Sigma(x-\bar{x})^2}{n-1}}$
L_{max} = SPECIFIED MAXIMUM LIMIT
L_{min} = SPECIFIED MINIMUM LIMIT
SOLUTION FOR n AND k
p_1 = DESIRABLY LOW VALUE OF FRACTION DEFECTIVE
p_2 = UNDESIRABLY HIGH VALUE OF FRACTION DEFECTIVE
α = RISK OF REJECTING QUALITY p_1
β = RISK OF ACCEPTING QUALITY p_2
FRACTION DEFECTIVE, p (NORMAL LAW DISTRIBUTION)
SAMPLE SIZE, n
PROBABILITY OF ACCEPTANCE, P_A (1-α, β)
k
P
P_A
n
β
p_1
p_2
1-α

where the quality characteristic under consideration is normally distributed. The solution assumes, as an approximation, that s is normally distributed with a mean of σ' and a standard deviation of $\sigma'/\sqrt{2(n-1)}$.

The assumptions used in deriving equation (1) and its limitation in application are fully discussed in Reference 3.

The nomograph accompanying this paper furnishes quick and convenient solutions to this fairly unwieldy equation, and can be used without further computation for:

(a) determining the k and n of plans given two points of the operating characteristic (e.g., p_1, p_2, α and β).
(b) determining the k of plans given one point of the operating characteristic (e.g., p_2 and β) and the sample size.
(c) obtaining operating characteristic curves for known plans; i.e., n and k are given.

The chart on letter size paper provides satisfactory results for sample sizes up to 100; its readability becomes poor for larger values of n. Like most nomographs, readability is limited by the size of the chart.

The use of the nomograph for each of the purposes listed above may be illustrated by the following examples.

Example 1

Determine an acceptance sampling plan using variables for the inspection of tensile strength of fine wire sections where the specified minimum limit, $L_{min.}$, is 15 pounds and $p_1 = .005$, $p_2 = .05$, with a risk $\alpha = 2\%$ applying at the p_1 fraction defective and a risk $\beta = 10\%$ for material at the p_2 level. Control charts made for sample data obtained from lots previously submitted for inspection showed no control for standard deviation (or range).

Solution

(a) Draw a straight line connecting the fraction defective, $p_1 = .005$, on the left hand vertical scale and the associated Probability of Acceptance, $1-\alpha = .98$, on the right hand vertical scale.
(b) Draw a straight line connecting the fraction defective, $p_2 = .05$, on the left hand scale and the associated Probability of Acceptance, $\beta = .10$ on the right scale.
(c) These two lines intersect on the grid between the two vertical scales at a point defined by $n = 39$ and $k = 2.00$ which determines an acceptance sampling plan that is described briefly as follows:
    1. Take 39 specimens of wire from each lot and obtain the tensile value of each specimen;
    2. Accept the lot if for the sample, $\bar{X} \geq L_{min.} + 2.00s$*.

Example 2

Economic considerations limit to a maximum of 8 the number of units that can be selected as a sample from a large lot. With this sample it is still desired to protect the consumer from accepting lots 3% defective more than 1 time in 10 on the average. What is the acceptance criterion?

Solution

(a) Draw a straight line connecting $p = .03$ on the left hand scale with $P_A = .10$ on the right hand scale.
(b) Where this line intersects $n = 8$ on the grid, read $k = 3.0$.
(c) Acceptance Criterion is
    $\bar{X} \geq L_{min.} + 2.85s$ (for a specified minimum limit), or
    $\bar{X} \leq L_{max.} - 2.85s$ (for a specified maximum limit).

Example 3

Given a sampling plan for variables defined by $n = 10$ and $k = 1.4$, what is its operating characteristic?

Solution

Locate the point on the grid where the line for $n = 10$ and the line for $k = 1.4$ intersect. Place a straight edge so that some selected value of fraction defective and this point are on a line. Where this line intersects the right hand scale read the corresponding probability of acceptance. For values of $p =$ fraction defective ranging from .005 to .20, the following listing of acceptance probabilities can be obtained directly from the chart.

Fraction Def. p	Prob. of Accept. P_A
.005	.995
.01	.98
.02	.92
.04	.78
.06	.63
.08	.50
.10	.40
.15	.22
.20	.11

* In actual practice, this acceptance criterion is arranged in a more useful form to minimize computational effort. See Reference 3, Page 66.

References

1. Dodge, H. F., and Romig, H. G., "Sampling Inspection Tables—Single and Double Sampling," John Wiley and Sons, Inc., New York, 1944.
2. Romig, H. G., "Allowable Average in Sampling Inspection," Columbia University, 1939.
3. Statistical Research Group, Columbia University, "Techniques of Statistical Analysis" (Chapter I)—McGraw-Hill Book Company, Inc., 1947.
4. Burgess, A. R., "A Graphical Method of Determining a Single Sampling Plan," Industrial Quality Control, May 1948.
5. Olds, E. G., "Acceptance Sampling by Variables"—ASQC Conference Papers, 1947.
6. Clifford, Paul C., "Acceptance Sampling Inspection by Variables," Industrial Quality Control, March 1947, Vol. III, No. 5, pp. 12-15.

MILWAUKEE—THE CONVENTION CITY

Quality control people all over the country are looking forward to the Fourth National Convention and the Fifth Midwest Quality Control Conference in Milwuakee on June 1 and 2, 1950. Progressive industry, geography, outstanding citizenry, and a public spirited educational system make Milwaukee a natural site for a quality control convention.

Milwaukee is the 10th largest industrial city in the nation. It is among the world's leaders in the fabrication of steel products, in the production of diesel and gasoline engines, outboard motors, motorcycles, tractors, wheelbarrows. Milwaukee is a large meat packing center, the greatest barley market, the location of four of the seven largest breweries in America. It leads in the production of men's, women's and children's hosiery, work shoes, leather gloves and mittens, tin and enamelware, saw and flour mill equipment. Milwau-

kee-made mining, dredging, and excavating equipment, power plants, pressure vessels for the oil, chemical, and paper industries, line pipe and machine tools, are used throughout the world. Motors, switches, controls, welding equipment extend, but by no means, exhaust the list of its products.

Milwaukee benefits from its location in the economically strong Great Lakes area of industrial concentration in addition to the rich agricultural regions which are at her immediate back door.

The Midwest area funnels toward Milwaukee great quantities of agricultural, timber, and mineral resources. Malt, soybeans, corn, canning and preserving crops, dairy products, furs, livestock, millwork and furniture, paper and paperboard, zinc, lead, iron—these are some of the fruits of the land.

Milwaukee's transportation facilities are excellent: access to all points on the Great Lakes and to foreign ports; three important railroad systems; four airlines; and daily truck service in all directions.

R. H. Markham of the *Christian Science Monitor* has said, "Milwaukee is beautiful. It is one of the world's most splendid cities and not surpassed by many of the world's capitals . . . Its waterfront, its vast parks, countless acres of lawns and miles of arched avenues are adornments which any city of the world might envy." World travelers like he have frequently compared Milwaukee's lake front, surrounded as it is by a crescent of hills, as rivaling and surpassing the beauties of the old world.

Milwaukee has the conveniences and appeal of a small city without losing any of the advantages of a large city. Greater Milwaukee has over 850,000 inhabitants.

Unexcelled facilities for relaxation and recreation are at your command in Milwaukee and Wisconsin to add zest to living. The Milwaukee County Park System compares favorably with the great municipal parks of the nation. In Wisconsin, and easily accessible over a fine highway system, or by air, boat, train or bus, are lakes, rivers, streams, and forests in a happy combination to afford relaxation and rest for all.

Milwaukee is a city of home owners and her people are nationally known for their thrift, skill, intelligence, and dependability. The 13th largest city in the nation, Milwaukee has the largest per capita night school enrollment in the United States and ranks second in this group of cities in per capita high school attendance.

EDITOR'S NOTE

This is the first of a series of four articles to appear in IQC. The articles are not the work of any one person or group, but represent rather the collaboration of Milwaukee and Wisconsin civic organizations and educational institutions. They will tell our readers about Milwaukee, its people, its industries, and its acceptance of quality control, and will unfold the general theme and setting of the 1950 joint ASQC Convention and Midwest Conference.

Helping to tie together and maintain these personal factors in Milwaukee, is a well designed educational system. The University of Wisconsin with an enrollment of 20,000 is more than an assortment of classes at Madison and at extension centers throughout the state where youth comes for general education and professional training. It carries on a vast amount of research in the natural and social sciences, to add to pure human knowledge and to help solve the practical problems of Wisconsin citizens. It conducts an array of vital public services which directly aid the people of the state.

One of the University of Wisconsin's most vigorous public service bureaus, and one directly connected with Milwaukee's controlled quality, is the Industrial Management Institute. For the 6th year institutes and seminars are being held on the Madison campus and around the state covering nearly every phase of management problems and providing an opportunity for up-to-date information for everyone from line foremen to company presidents. The University of Wisconsin Industrial Management Institute was the first of its kind in the country. It is performing a highly significant function in the solving of labor-management and production difficulties through better trained management executives and supervisors.

Industrial quality control is an important phase of the intensive training programs carried on by the Institute. Through cooperation with the American Society for Quality Control, the University of Wisconsin is a partner of industry.

Marquette University with its fine Engineering School and its plan of cooperative education and training with industry is developing young men to assume their places in the industrial life of the nation.

Adult and vocational education is possible through Milwaukee's outstanding Vocational School. The importance of vocational and adult education was demonstrated in Milwaukee last December when 400 persons from all parts of the United States attended the National Convention of the American Vocational Association in Milwaukee. It is possible to obtain training in practically any subject at the Milwaukee Vocational and Adult Schools. Instruction in quality control techniques is one of the courses regularly given.

The quality control movement began in the Milwaukee area following the attendance of 8 men from Milwaukee industry at a training session at the State University of Iowa in 1945. These men organized the Milwaukee Society for Quality Control and held their first meeting on January 16, 1946. This organization, now known as the Milwaukee Section, American Society for Quality Control, one of 38 such sections throughout the United States, has grown steadily, indicating the increasing acceptance of these methods by industry in this area.

The people of Milwaukee join with the 11 Midwest Sections to welcome the members and friends of the American Society for Quality Control to a quality conscious city, proud of its industry, its geography, its educational facilities, and of its plans for the development of itself, the state, and the nation.

NOTICES

1. Effective with the January 1950 issue of IQC, the rate for a "Position Wanted" ad will be 25c per line per insertion to *corporate members* of ASQC. See p. 29, Jan. 1948 issue for other details for these ads.

2. The new Information Folder is now available. Section Secretaries should forward their requests for their supply to Simon Collier, Executive Secretary, ASQC.

Operator Interest and Cooperation in Statistical Quality Control*

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A POOR START WITH SQC

When first considering the problem of starting a statistical quality control program, we decided that two things would be important to assure initial success. We were very concerned about initial success, because very often an initial failure will, at least, seriously deter a program of this nature. The two elements we considered to be of primary importance were: (1) select a spot where installation of charts would be easy, and (2) have the work of charting done by carefully selected and trained personnel. Not much thought was given to the actual operators whose work was to be checked. The persons chosen to make measurements and then set up the necessary charts were carefully coached in all the technical details of the problem. They were also told emphatically that they must report facts only, that opinions were valueless.

The first installation was not a success; outwardly it was a failure. But good experience was gained and certain facts were established. One fundamental thing we learned was the importance of the operator. Another thing we learned was that it is a mistake to attempt to break into the middle of a process and start control: the place to start is at the beginning. The material processed had to be uniform to get successful processing. During the progress of the work on controls we gained an entirely new appreciation of uniformity. Also, we found that equipment was not always what it seemed. Of course a lot of this information was of such a nature that it seriously questioned some of the pet theories and opinions of a lot of operators. The "operators" thought of in this sense were not only the operators on the machine but also supervision and management. Probably the only thing about the initial program that proved to be correct was the contention that whoever did the work of measuring and charting must deal in facts only. This is certainly important and has been the keynote of all of our work. Facts and facts only. Opinions lead to arguments and arguments lead to bad relations.

A PROGRAM THAT SUCCEEDED

After carefully studying what had been learned, we made a new start, this time at the beginning of the process. In a rubber factory, the beginning process is the mixing operation. Here the necessary chemicals are mixed with the rubber. Since this is a rather intricate and difficult process, we had initially decided to by-pass it in order to get at something easier. However, the facts said that here was the place to start.

Considerable opposition arose immediately. Supervision was thoroughly convinced that to attempt controls, would offer so much interference as to make the effort useless. The machine operator was afraid of controls because some of his bad practices might be exposed; in particular he was afraid that controls would affect his pay. During the first discussion of the subject, the division superintendent flatly refused to permit work of this kind to be done in his division. Incidentally too, the Union did not look very kindly on our "control" proposals.

Rather than use existing prerogatives and force the program in, a selling program was instituted. Sufficient basic data had been gathered so that a nice picture of the benefits derived from the control could be shown. This was carefully prepared as propaganda and then applied. Our selling program proved successful; it was not too long until the attitude developed that if we could not get actual help in the program, we would at least have no opposition. On this basis, a program of control was started.

As mentioned before, the mixing problem is quite complex, and to start a complete program was deemed to be impractical at the start, so one element was selected. On the mixing machines, a temperature recorder is used. This temperature recorder is of the continuous strip type. The element we chose to measure was the total time of the batch. Again, selection of personnel to do this original job was given careful consideration. Individuals were chosen who had enthusiasm, and who were willing to work under adverse conditions. They were also schooled in getting facts, and in the necessity of being diplomats. It was a tough assignment because these people really accepted quite a responsibility with little authority. Much credit goes to them for the success of the program. They used noteworthy ingenuity to promote the program.

The procedure followed was to take the strip chart and analyze it each day, and then to present this analysis on a sample chart which showed the operator the batches that were in tolerance. An idea that helped particularly well was to develop a spirit of competition between operators. Operators were naturally skeptical, so particular stress was placed on showing them how a chart would help them. They were shown that this chart was the actual story of the day's performance which reflected the good work and the bad impartially. By knowing the wrong things that happened and determining the cause, corrections could be made. The operators were encouraged to write down their troubles, and every assistance was given them to make corrections. By this means confidence in the system was built up and some operators started showing some good charts. The first operator that ran an entire day in control was so proud of his record, he did not wait for compliments, he asked for them.

* Presented at the Third Midwest Quality Control Conference, Chicago, Ill., November 4, 1948.

As pertinent facts were established and proved, they were immediately acted upon. As a final result the wage payment system was adjusted, batch times were corrected, equipment was repaired and generally brought up to top level efficiency. When the job was finally brought under control the results obtained were such that everybody immediately became a promoter of control charts. The operators were pleased because the facts presented had helped them; management was pleased because of increased efficiency of costly equipment. More stock was mixed per day than ever before and the stock was of a level of quality never before obtained.

After the successful establishment of the first chart system, the need was felt for more trained personnel. A training course in statistical methods for quality control was arranged and conducted by Mr. J. Heide. This course was first given to all personnel of the Quality Control Department. As more jobs were covered it became apparent that supervision would be benefited by a better grasp of the problem. A similar course was then offered to all supervisors and foremen. It was obviously not the intent to make statisticians out of everybody, but this kind of training is helpful. To try to discover facts and use facts rather than opinions is the most satisfactory approach to any problem.

OPERATOR INTEREST ESSENTIAL TO SQC

Each operation or process needs its own approach, but some of the general things that have helped might be reviewed. A good way to get the confidence of the operator is to let him make his own chart. This of course is not possible in all cases, but generally he can help supply some information. The objection that this might lead to doctored charts is of little importance if the operator is shown that this is his chart and that it is there to help him do a better job. Try to teach him that it is better to make a record of what he is doing than to try to remember.

Certainly no job can be successful without the personal interest of the operator. One of the best ways that we found to get the interest of the operator was to attempt to make him a part of the program. In other words, put him on the team. Many of the problems arising from modern production methods no doubt come from the fact that the operator knows very little about what goes on or what is required other than his immediate little job. By taking him into the team and giving him an important part to play, you make him a better operator and are repaid in a better product. To attempt to force any method or any program into any job is merely to ask for trouble. It is still a lot easier to lead people than it is to drive them. One may be reminded of the old fable from the school books about the man and the donkey. The donkey was obstinate and could not be driven, but when the man held a carrot before the donkey's nose, the donkey followed gladly. Try to look for the carrot—it works!

One Important Aspect of SQC

G. M. HAILES

TAYLOR INSTRUMENT COMPANIES

February, 1949

To: Members of Staff

Subject: Statistical Quality Control

Attached is a brief memorandum which attempts to outline one aspect of quality control work. It is hoped that this will help to avoid a certain type of misunderstanding which seems to arise at least once in any quality control program anywhere.

No specific action on this matter is requested of you. It would be appreciated, however, if you would read over the attached note. Please give me a ring if the intent is not clear, or if you should disagree with any phase of it. In the future, it is possible that you may be in a position where you can be of great assistance to us simply by explaining our position and function to any of your people who appear to misunderstand it.

G. M. Hailes
Quality Control Engineer

ONE IMPORTANT ASPECT OF QUALITY CONTROL WORK

One of the primary duties of a Quality Control Department is to investigate high rejection rates to determine the cause of this condition. Depending upon the nature of the defect, such investigations will themselves vary considerably in nature. When a specific condition of high rejections is investigated, the cause will generally be found to be one or more of the following:

(1) Failure of the Manufacturing Department to follow established standard methods, specifications, or techniques, or to properly supervise the work.

(2) Failure of the Design Engineering Department to specify proper dimensions, tolerances, materials, etc.

(3) Failure of one of the Service Departments to provide proper methods, tools, equipment, gages, time standards, etc.

(4) A justified precision requirement beyond the capabilities of any practicable economic method to produce.

A successful investigation of high rejection rates is almost certain to prove to be a headache for someone. It so happens that if the trouble is due to a dimension, tolerance, or standard, then the quantitative information which we have gathered to discover the trouble is such that it may almost automatically fix the required change within very close limits. If a tolerance is wrong for example, the control charts will probably show to what extent the tolerance should be altered. If a method is wrong, it is necessary to know of some better method before it can be pointed out that the existing method is "wrong."

So the trail which starts with the question—"What is the cause of these

rejections?", may lead us through the domains of several departments, each naturally jealous of its sacred prerogatives, and it usually ends up with the discovery of a skeleton in someone's closet. The situation is completely impartial; we are not trying to usurp anyone's prerogatives, not trying to "hang anything" on anybody. We are interested only in one thing: *securing action to reduce the rejects.* In the sense that we are working to improve quality, reduce scrap costs, increase the bonus, improve job security, etc., we are working for the common good. But since we may of necessity uncover some "fault" in anyone's work our fundamental purpose may be forgotten. Although we all make mistakes, few of us are "big" enough to always react to their discovery in a purely constructive manner. Some people may react in a downright hostile manner.

Such people are apt to "take a burn," chiefly because they forget our purpose, and do not understand the method. They may temporarily forget that it is just our job to reduce scrap, and hence to seek the cause of the scrap whatever the cause may be. They probably do not understand the statistical approach to the problem, and generally do not appreciate the power of statistical methods to deal with complex situations and to unearth information which may have been literally under their noses for many years.

Following is a statement by Charles F. Kettering. He was speaking of research, but his remark applies so aptly to quality control that the words "quality control" have been substituted for the original "research":

> "The greatest durability contest in the world is getting a new idea into any factory. It is well if management understands this and will constitute itself the sales department for the quality control organization. Otherwise the hard-boiled men in the factory will put quality control men out of business in a fortnight. When we present a new idea to people, their first instinctive reaction is against it. Nobody likes change. That is the one great thing you must understand in the psychology of quality control."

Not only is "quality control" itself a change to many companies, but its successful application to any given problem usually requires some change. If it is desired to reduce scrap, or to improve quality, or to obtain better fits, then *something must be changed.* The required change may be in a tolerance method, or standard, or in some foreman's attitude or worker's technique.

So we must often compound the double sin of pointing out an error, and proposing a change. To use Mr. Kettering's words: It is well if you understand this and will constitute yourself a sales department for the Quality Control organization.

Practical Aids

ELLIS R. OTT, Editor

1.—A Check on Some Inspection Data*

WILLIAM R. PABST

NAVY DEPARTMENT, WASHINGTON, D. C.

A single sampling inspection plan was used by the Navy Department, Bureau of Ordnance, as the basis for accepting and rejecting lots of 3"/50 projectiles. The inspection plan required a sample of 75 projectiles from each lot; the lot was accepted if not more than 2 defectives were observed and rejected if 3 or more were observed (i.e., $n = 75$, $c = 2$). A summary of the inspection data showed that 192 defectives had been observed during the examination of 10,800 sample projectiles from the last 144 lots. Thus the observed average percent defective was:

$$\bar{p} = 192/10{,}800 = 1.78\%.$$

* Analysis and data supplied by Quality Control Division, Bureau of Ordnance, Navy Department, under date of 1 November 1948.

Send your "Practical Aid" contribution to:

Dr. Ellis R. Ott, Rutgers University
77 Hamilton Street
New Brunswick, N. J.

When a summary of the observed frequencies was prepared for the 144 lots (Column 1) it seemed peculiar to find such a sudden break between the large number of samples containing 2 defectives and the absence of any samples containing 3 defectives, especially when this break was the dividing line between acceptance and rejection of the lots. The purpose of this note is to apply a standard procedure to determine whether or not the inspection data are "reasonable."

The probabilities for samples of 75 to contain 0, 1, 2, . . . , 7 defective items have been determined on the basis of a Poisson distribution corresponding to $\bar{p} = 1.78\%$, and are shown in Column 2.** Values contributing to chi-square (χ^2) are shown in Column 3.

There are 5 groups contributing to the value of $\chi^2 = \Sigma(f_o - f_e)^2/f_e$. Since we have imposed the additional restric-

** The terms of the Poisson distribution are $m^n e^{-m}/n!$. In this example, $m = \bar{p}n = (.0178)(75) = 1.33$. Then the terms of Column 2 can be computed for $n = 0, 1, 2, \ldots, 7$ from the tables of e^{m} and $n!$ or found directly in Poisson's *Exponential Binomial Limit*, E. C. Molina, 1947, D. Van Nostrand Company, New York.

tion that $m = 75(.0178) = 1.33$ in setting up the data of Column 2, the degrees of freedom (d. f.) will be $(5-1)-1 = 3$. A χ^2 table, corresponding to 3 d. f., indicates that the observed frequencies are very improbable on the basis of sampling fluctuation; in fact, the probability is less than .001. The major portion of χ^2 is contributed from (a) the unusually large number of samples observed to contain exactly 2 defectives and (b) the failure to observe any samples containing 3 defectives. Evidently an explanation of the observed inspection data must include a bias in the inspection process.

The reasonableness of this conclusion can be checked by considering values of

$$n\bar{p} \pm 3\sqrt{n\bar{p}(1-\bar{p})}$$

at each of the two suspicious frequencies which were observed. If we agree that 23.4% of the 144 lots can be expected to contain 2 defectives, then:

$$n\bar{p} \pm 3\sqrt{n\bar{p}(1-\bar{p})}$$

No. of Defectives in Sample		(1) Observed Frequency, f_o	(2) Expected frequency: Percent	(2) Expected frequency: No. of Lots, f_e	(3) $(f_o-f_e)^2/f_e$
0	Accept lot	36	26.4	38	0.2
1	Accept lot	46	35.1	50	0.3
2	Accept lot	56	23.4	34	14.2
3	Reject lot	0	10.4	15	15.0
4	Reject lot	2	3.5	5	
5	Reject lot	0	0.93		0.1
6	Reject lot	2 ***	0.21 1.2	2 ***	
7	Reject lot	2	0.04		
	Totals	144	100%	144	$\chi^2 = 29.8$

$$= 34 \pm 3\sqrt{34(.766)}$$
$$= 34 \pm 15+$$
$$= 49+, \text{ and } 19-.$$

Similarly, corresponding to an expected 10.4% of the lots to contain 3 defectives, we would have

$$n\bar{p} \pm 3\sqrt{n\bar{p}(1-\bar{p})}$$
$$= 15 \pm 3\sqrt{15(.896)}$$
$$= 15 \pm 11-,$$
$$= 26-\text{and } 4+.$$

These three-sigma limits were exceeded in each of the two categories; more than 49 lots were observed in the one, and fewer than 4 in the other.

*** In general it is not advisable to use the χ^2 test when any expected class frequency is less than 5. The difficulty was avoided here by pooling classes. See Chapter V of *Industrial Experimentation*, K. A. Brownlee, Chemical Publishing Co., Inc., Brooklyn, N. Y., 1947.

2.—Variables Control Chart in Production Research

ELLIS R. OTT

RUTGERS UNIVERSITY

During the manufacture of phonograph pick-up assemblies in a plant of Sonotone Corporation, an electrical characteristic of the completed assemblies was more variable than desired.

In an effort to manufacture the units with greater uniformity, attention was directed toward a ceramic component of the assembly. These component pieces were cut in the plant from ceramic strips purchased from an outside vendor; some 25 individual pieces were obtained from each ceramic strip. The production foreman and engineer agreed that it was worthwhile to determine how the variability of assemblies containing pieces cut from different strips would compare with the variability corresponding to different pieces from a single strip.

It was decided arbitrarily to cut 7 pieces from each of 11 different strips. The eleven sets were used to complete eleven assemblies by putting them through the regular production process. The following readings of the electrical characteristics of the final assemblies were then read and recorded as shown in Table 1.

A variables control chart was then prepared from these averages and ranges (See Figure 1). The points were not connected, however; these samples do not represent production with respect to time, but a record of 11 samples made from 11 different ceramic strips.

The range of Sample No. 9 was large and the average was low, essentially from the influence of the 10.9 reading. However, the production engineer recognized this low reading as resulting from an electrical short in the assembly, and advised that this one reading be disregarded.

Values of $\bar{\bar{X}}$ and $\bar{R}$ were computed from the remaining ten sets of samples to be:

$$\bar{\bar{X}} = 15.95,$$
$$\bar{R} = 2.49.$$

The dotted control limits in the figure were determined as follows:

$$\bar{\bar{X}} \pm A_2\bar{R} = 15.95 \pm (.419)(2.49)$$
$$= 17.00 \text{ and } 14.90,$$
$$D_4\bar{R} = (1.924)(2.49) = 4.8,$$
$$D_3\bar{R} = (\ .076)(2.49) = \ .2.$$

Except for Sample No. 9, the points lie comfortably within control limits as computed from the 10 samples. Thus the tentative hypothesis that the variability resulting from between strips would be greater than the variability resulting from pieces within strips has not been justified. If the variability from within strips were significantly less than from between strips, then it would have been desirable to establish inspection criteria to accept only certain strips for production, while working with the vendor in an attempt to obtain more uniform strips.

TABLE 1

Set	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11
	16.5	15.7	17.3	16.9	15.5	13.5	16.5	16.5	14.5	16.9	16.5
	17.2	17.6	15.8	15.8	16.6	14.5	14.3	16.9	14.9	16.5	16.7
	16.6	16.3	16.8	16.9	15.9	16.0	16.9	16.8	15.6	17.1	16.3
	15.0	14.6	17.2	16.8	16.5	15.9	14.6	16.1	16.8	15.8	14.0
	14.4	14.9	16.2	16.6	16.1	13.7	17.5	16.9	12.9	15.7	14.9
	16.5	15.2	16.9	16.0	16.2	15.2	15.5	15.0	16.6	13.0	15.6
	15.5	16.1	14.9	16.6	15.7	15.9	16.1	16.1	10.9	15.0	16.8
$\overline{\overline{X}}$	16.0	15.8	16.4	16.5	16.1	15.0	15.9	16.3	14.6	15.7	15.8
$\overline{R}$	2.8	3.0	2.4	1.1	1.1	2.5	3.2	1.9	5.9	4.1	2.8

The 11 sets of ceramic pieces were made into completed assemblies by one group of operators in about an hour's production time. This was done deliberately since the purpose of the production experiment was to determine possible effects resulting from different strips of ceramics. If different sets had been done by different shifts and on different days, it was entirely possible that unintentional differences in processing might cause significant variations which would then be confused with the effects being considered in this simple but effective experiment.

Although this method of designing an experiment and of analyzing the resulting data by the control chart method is very efficient, it is not in general usage. It has an added advantage in that an explanation can be made convincing to a non-statistician.

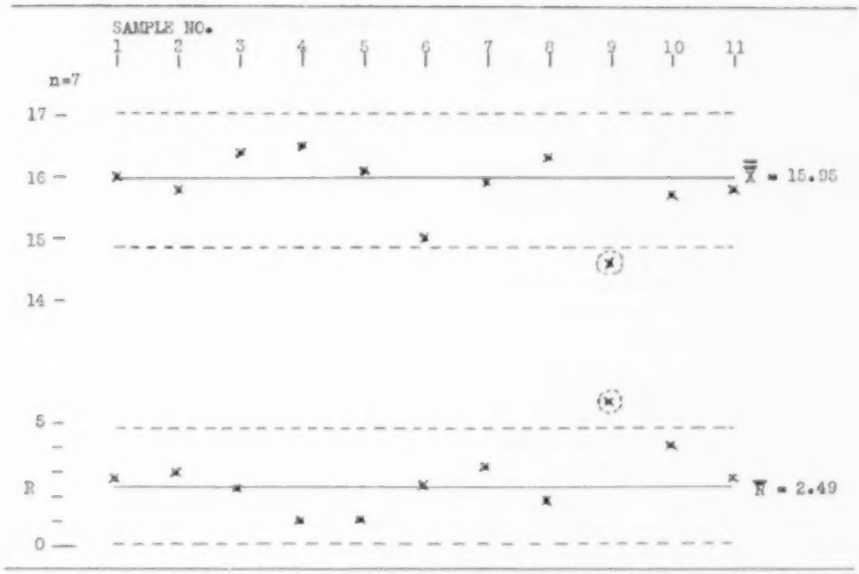

FIGURE 1—CONTROL CHARTS FOR DATA OF TABLE 1

AMERICAN SOCIETY NEWS

NEW ENGLAND SECTIONS MAKE SUSTAINING CONTRIBUTION

The Society acknowledges with deep appreciation a gift of $500 from the four New England Sections which sponsored the Society's Third Annual Convention in Boston last May. This Sustaining Contribution to the American Society has been made possible through the capable handling of the Third Annual ASQC Convention by the Convention Committee under the chairmanship of Mr. W. R. Purcell.

The Executive Committee has expressed its thanks to the Boston Convention Committee and to the four Sections which sponsored the Convention: Boston, Hartford, Southern Connecticut, and Western Massachusetts. The $500 gift has been placed in a separate Society savings account for future use in furthering quality control through the activities of the American Society.

BOARD OF DIRECTORS 1949-50

The terms of Directors representing the following Sections expired on June 30, 1949: Baltimore, Boston, California, Delaware, Hartford, Indiana, Metropolitan, Michigan, Mid-Hudson, Minnesota, New Hampshire, Ohio, Philadelphia, Rochester, South Texas, Southern Connecticut, Syracuse, and Western Massachusetts. These Sections have now chosen new Directors to represent them on the American Society Board for the term ending June 30, 1951.

The Toledo Section, which was accepted as the 36th Section of the Society in July, has appointed its Director for the term ending June 30, 1950.

With the selection of these new Directors, the Board of Directors for 1949-50 is now complete and is constituted as follows:

Chairman:

Ralph E. Wareham, President
Wade R. Weaver, Vice President

Secretary:

Simon Collier, Executive Secretary

Directors:

George D. Edwards, Past President
Alfred L. Davis, Treasurer
Mason E. Wescott, Chairman, Editorial Board
B. B. Day, Baltimore
Leonard A. Seder, Boston
Wilbur L. Burns, Buffalo
Wyatt H. Lewis, California
Ernest H. Robinson, Chicago
Maurice Rosenblatt, Cincinnati
C. E. Stines, Dayton
Joseph R. Nixon, Delaware
Ralph A. Hefner, Georgia
Dorian Shainin, Hartford
A. C. Richmond, Illinois
George W. McDermott, Indianapolis
F. J. Halton, Jr., Iowa
Eugene H. MacNiece, Metropolitan
Leo R. Harrington, Michigan
O. Herbert Somers, Mid-Hudson
Raymond S. Saddoris, Milwaukee
G. G. Parkin, Minnesota
Halmond L. Parks, Muncie
Herman D. Edgerly, New Hampshire
T. T. McNelley, N. E. Indiana
J. Frederick Verigan, Ohio
Ralph J. Knoll, Philadelphia
Robert E. Wagonhals, Pittsburgh
Halsey H. Kent, Rochester
B. E. Burridge, Rock River Valley
Kort K. Pfabe, St. Louis
T. L. Noel, South Texas
Charles D. Ferris, Southern Conn.
Paul A. Robert, Southern Tier
Joseph R. Sadowski, Syracuse
James A. Mitchell, Tennessee
Julian H. Toulouse, Toledo
R. J. D. Gillies, Toronto
A. L. Robertson, Washington
Gerald H. Cassady, Western Mass.

EXECUTIVE COMMITTEE 1949-50

New Regional Directors having been duly chosen to succeed all of those whose terms have expired, the Executive Committee of the Society for 1949-50 is now complete and is constituted as follows:

Chairman:

Ralph E. Wareham, President
Wade R. Weaver, Vice President

Secretary:

Simon Collier, Executive Secretary

George D. Edwards, Past President
Alfred L. Davis, Treasurer
Mason E. Wescott, Chairman, Editorial Board
Dorian Shainin, Regional Director—New England
Bessie B. Day, Regional Director—Middle Atlantic
O. Herbert Somers, Regional Director—Northern
Ralph A. Hefner, Regional Director—Central
Fred J. Halton, Jr., Regional Director—Midwest
Wyatt H. Lewis, Regional Director—Western

The new Executive Committee held its first meeting on Sunday and Monday, October 2 and 3, in New York City. Action taken at that meeting is reported below.

EXECUTIVE COMMITTEE MEETS

A successful meeting of the Executive Committee was held in the Johns-Manville Building, New York City, on Sunday and Monday, October 2 and 3. All but two of the twelve members of the Executive Committee were present or were represented by alternates.

Through the courtesy of Johns-Manville Corporation, the Executive Committee was invited to use the J-M Board of Directors Room for the meeting and to be guests of J-M for luncheon on Monday. This hospitality was much appreciated by all members of the Executive Committee.

Executive Secretary Collier reported satisfactory progress by most Sections in their membership renewals. He also reported a substantial number of new members (257) joining the Society this year and bringing total membership to a record high.

Treasurer Davis reported that the Society's operating account at the start of the current Society year was $3,901.11. During the first three months of this year, receipts totaled $6,359.54 and expenditures amounted to $4,381.39; the balance on hand at September 30 was $5,879.26.

The Executive Committee carefully reviewed the audited financial statements prepared by Ernst and Ernst for the Society year ended June 30, 1949. The statements of income and expense, together with accounting accruals made by the auditors, indicated that the Society operated at a deficit of approximately $450 during the 1948-49 year. The Executive Committee carefully reviewed all Society operations and commitments for the 1949-50 year, so as to avoid any deficit in the current year.

A Society budget with expected income of $20,350 and planned expenditures of $20,010 was adopted for this year. The Treasurer will prepare quarterly statements comparing actual operations with this budget.

The Executive Committee endorsed the President's request made in July to each Section Chairman that every Section of the Society achieve at least a 10% membership increase this year with a minimum of 50% of total memberships to be in the Senior Member Grade. Each Regional Director will be directly responsiible for working with the Sections in his Region to achieve these minimum goals.

Mason E. Wescott, Chairman of the Editorial Board, presented plans for magazine changes and improvements. Ellis R. Ott has assumed editorship of the "Practical Aids" section of the magazine; A. C. Cohen will head the "Book Review" section. The Editorial Board and the Advertising Committee are cooperating closely in matters relating to advertising in the magazine.

Plans for the 1950 Convention in Milwaukee and the 1951 Convention in Cleveland were reviewed. The President was authorized to appoint a General Convention Committee of the Society to carry on continuing work with all conventions and regional conferences.

A program was started for extending the activities of Regional Directors in Society relationships with individual Sections.

NOMINATING COMMITTEE 1949-50

The President has appointed, with Executive Committee approval, the following Directors to serve as members of the Nominating Committee for 1949-50:

George D. Edwards, Chairman
Ralph A. Hefner
Wyatt H. Lewis
Eugene H. MacNiece
Paul A. Robert
Ernest H. Robinson
Dorian Shainin

As provided in Section 52 e. of the Constitution, the Nominating Committee consists of the Junior Past President and one Director appointed from each of the six Regions of the Society.

The Nominating Committee has been requested to begin its work immediately and to present its report not later than December 31, 1949.

NEW SECTIONS RECOGNIZED

At its meeting in New York on October 2 and 3, the Executive Committee had the pleasure of approving the applications of two new quality control groups as Sections of the American Society for Quality Control.

The Columbus Section was approved as the 37th Section of the Society. Its headquarters will be in Columbus, Ohio; the Section will be part of the Central Region.

The Denver Section was approved as the 38th Section of the Society. Its headquarters will be in Denver, Colorado; the Section will be part of the Western Region.

The Society extends its warm welcome to both of these new Sections, located as they are in important industrial areas.

FOURTH ANNUAL CONVENTION ASQC

Plans are well advanced for the Fourth Annual Convention of the Society to be held at the Milwaukee Auditorium in Milwaukee on Thursday and Friday, June 1 and 2, 1950. The eleven Midwest Sections of ASQC will be host to the Convention which is to be held in conjunction with the Fifth Annual Midwest Quality Control Conference.

Mr. Raymond S. Saddoris, General Chairman of the Convention, has announced that the Midwest Sections are working to provide a program of wide general interest to members of the Society. The meetings should be of outstanding importance in quality control affairs.

At the Annual Society Dinner, presentation will be made of the Shewhart Medal and of the first Brumbaugh Award.

It is important that all Sections of the Society note the dates of June 1 and 2 in their Section calendars and take steps to avoid any conflicts in program during these days, so that as many members as possible may be together at the Milwaukee Convention.

1949 SHEWHART MEDAL

Mr. P. L. Alger, Chairman of the Shewhart Medal Committee, has announced that nominations for the 1949 Shewhart Medal may be made by any member of the Society, or groups of members, or Sections, until the closing date of January 31, 1950. Nominations should be sent directly to Mr. P. L. Alger at the General Electric Company, Schenectady, New York.

Any person who, in the opinion of the Shewhart Medal Committee, is noted for outstanding leadership in the field of modern quality control is eligible for the award. This accords with the inscription on the medal itself. Persons who are not members of the Society, both at home and abroad, are eligible, but preference will be given to Society members.

The Shewhart Medal will be presented to the 1949 Medallist at the Milwaukee Convention on June 1, 1950.

In addition to Mr. Alger, members of the Shewhart Medal Committee are: C. A. Bicking, E. L. Fay, I. S. Hoffer, G. R. Gause, A. I. Peterson, W. R. Purcell, C. E. Stines, and P. A. Robert.

BRUMBAUGH AWARD

The Brumbaugh Award Committee is now hard at work reviewing recommendations made by Society members for the first Brumbaugh Award. From these recommendations, the Committee will select the paper published in Industrial Quality Control which is judged to have made the greatest contribution to the development of industrial applications of quality control. Papers published in the magazine from July 1944 to June 1949 are eligible for this year's award.

The first Brumbaugh Award of $50 will be presented at the Milwaukee Convention next June.

Members of the Brumbaugh Award Committee are: H. H. Kent (Chairman), C. S. Barrett, P. D. Deans, J. J. Ferri, Wyatt H. Lewis, H. H. Sheaffer, C. R. Scott, and M. E. Wescott.

Book Reviews

A. C. COHEN, JR., Editor

ELEMENTARY STATISTICAL ANALYSIS

S S. Wilks, Professor of Mathematics, Princeton University. Princeton University Press, Princeton, N. J., 1948: xi+280 pages; $2.50. Review by W. Edwards Deming, Bureau of the Budget, Washington 25, D. C.

At last, here is a real text book for the study of statistics. The science of statistics has made important advances during the past few years, but unfortunately, with but few exceptions, elementary statistical text books, although they have appeared in numbers, have not reflected the newer types of thinking, nor laid a foundation for the same. This book sets new standards.

Correspondence and suggestions concerning book reviews should be sent to
Professor A. C. Cohen, Jr.
Department of Mathematics
University of Georgia
Athens, Ga.

The mathematical level fits the requirements of freshmen at Princeton. The time is past when a first course in statistics, either for intending statisticians or for intending students in quantitative subject-matter, is expected to be completely non-mathematical. The style is clear, and anyone with high school algebra can study the book. The inspiration that a student derives from it may be expected to result in further mathematical and statistical pursuits.

The central theme seems to the reviewer to be the correct one, namely, that statistical data are taken as a basis for action. This is made clear in Chapter 1, the introduction, wherein a number of examples are given in the uses of data. A problem is stated; informa-

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Maurice Rosenblatt, Cincinnati
C. E. Stines, Dayton
Joseph R. Nixon, Delaware
Ralph A. Hefner, Georgia
Dorian Shainin, Hartford
A. C. Richmond, Illinois
George W. McDermott, Indianapolis
F. J. Halton, Jr., Iowa
Eugene H. MacNiece, Metropolitan
Leo R. Harrington, Michigan
O. Herbert Somers, Mid-Hudson
Raymond S. Saddoris, Milwaukee
G. G. Parkin, Minnesota
Halmond L. Parks, Muncie
Herman D. Edgerly, New Hampshire
T. T. McNelley, N. E. Indiana
J. Frederick Verigan, Ohio
Ralph J. Knoll, Philadelphia
Robert E. Wagonhals, Pittsburgh
Halsey H. Kent, Rochester
B. E. Burridge, Rock River Valley
Kort K. Pfabe, St. Louis
T. L. Noel, South Texas
Charles D. Ferris, Southern Conn.
Paul A. Robert, Southern Tier
Joseph R. Sadowski, Syracuse
James A. Mitchell, Tennessee
Julian H. Toulouse, Toledo
R. J. D. Gillies, Toronto
A. L. Robertson, Washington
Gerald H. Cassady, Western Mass.

EXECUTIVE COMMITTEE 1949-50

New Regional Directors having been duly chosen to succeed all of those whose terms have expired, the Executive Committee of the Society for 1949-50 is now complete and is constituted as follows:

Chairman:

Ralph E. Wareham, President
Wade R. Weaver, Vice President

Secretary:

Simon Collier, Executive Secretary

George D. Edwards, Past President
Alfred L. Davis, Treasurer
Mason E. Wescott, Chairman, Editorial Board
Dorian Shainin, Regional Director—New England
Bessie B. Day, Regional Director—Middle Atlantic
O. Herbert Somers, Regional Director—Northern
Ralph A. Hefner, Regional Director—Central
Fred J. Halton, Jr., Regional Director—Midwest
Wyatt H. Lewis, Regional Director—Western

The new Executive Committee held its first meeting on Sunday and Monday, October 2 and 3, in New York City. Action taken at that meeting is reported below.

EXECUTIVE COMMITTEE MEETS

A successful meeting of the Executive Committee was held in the Johns-Manville Building, New York City, on Sunday and Monday, October 2 and 3. All but two of the twelve members of the Executive Committee were present or were represented by alternates.

Through the courtesy of Johns-Manville Corporation, the Executive Committee was invited to use the J-M Board of Directors Room for the meeting and to be guests of J-M for luncheon on Monday. This hospitality was much appreciated by all members of the Executive Committee.

Executive Secretary Collier reported satisfactory progress by most Sections in their membership renewals. He also reported a substantial number of new members (257) joining the Society this year and bringing total membership to a record high.

Treasurer Davis reported that the Society's operating account at the start of the current Society year was $3,901.11. During the first three months of this year, receipts totaled $6,359.54 and expenditures amounted to $4,381.39; the balance on hand at September 30 was $5,879.26.

The Executive Committee carefully reviewed the audited financial statements prepared by Ernst and Ernst for the Society year ended June 30, 1949. The statements of income and expense, together with accounting accruals made by the auditors, indicated that the Society operated at a deficit of approximately $450 during the 1948-49 year. The Executive Committee carefully reviewed all Society operations and commitments for the 1949-50 year, so as to avoid any deficit in the current year.

A Society budget with expected income of $20,350 and planned expenditures of $20,010 was adopted for this year. The Treasurer will prepare quarterly statements comparing actual operations with this budget.

The Executive Committee endorsed the President's request made in July to each Section Chairman that every Section of the Society achieve at least a 10% membership increase this year with a minimum of 50% of total memberships to be in the Senior Member Grade. Each Regional Director will be directly responsiible for working with the Sections in his Region to achieve these minimum goals.

Mason E. Wescott, Chairman of the Editorial Board, presented plans for magazine changes and improvements. Ellis R. Ott has assumed editorship of the "Practical Aids" section of the magazine; A. C. Cohen will head the "Book Review" section. The Editorial Board and the Advertising Committee are cooperating closely in matters relating to advertising in the magazine.

Plans for the 1950 Convention in Milwaukee and the 1951 Convention in Cleveland were reviewed. The President was authorized to appoint a General Convention Committee of the Society to carry on continuing work with all conventions and regional conferences.

A program was started for extending the activities of Regional Directors in Society relationships with individual Sections.

NOMINATING COMMITTEE 1949-50

The President has appointed, with Executive Committee approval, the following Directors to serve as members of the Nominating Committee for 1949-50:

George D. Edwards, Chairman
Ralph A. Hefner
Wyatt H. Lewis
Eugene H. MacNiece
Paul A. Robert
Ernest H. Robinson
Dorian Shainin

As provided in Section 52 e. of the Constitution, the Nominating Committee consists of the Junior Past President and one Director appointed from each of the six Regions of the Society.

The Nominating Committee has been requested to begin its work immediately and to present its report not later than December 31, 1949.

NEW SECTIONS RECOGNIZED

At its meeting in New York on October 2 and 3, the Executive Committee had the pleasure of approving the applications of two new quality control groups as Sections of the American Society for Quality Control.

The Columbus Section was approved as the 37th Section of the Society. Its headquarters will be in Columbus, Ohio; the Section will be part of the Central Region.

The Denver Section was approved as the 38th Section of the Society. Its headquarters will be in Denver, Colorado; the Section will be part of the Western Region.

The Society extends its warm welcome to both of these new Sections, located as they are in important industrial areas.

FOURTH ANNUAL CONVENTION ASQC

Plans are well advanced for the Fourth Annual Convention of the Society to be held at the Milwaukee Auditorium in Milwaukee on Thursday and Friday, June 1 and 2, 1950. The eleven Midwest Sections of ASQC will be host to the Convention which is to be held in conjunction with the Fifth Annual Midwest Quality Control Conference.

Mr. Raymond S. Saddoris, General Chairman of the Convention, has announced that the Midwest Sections are working to provide a program of wide general interest to members of the Society. The meetings should be of outstanding importance in quality control affairs.

At the Annual Society Dinner, presentation will be made of the Shewhart Medal and of the first Brumbaugh Award.

It is important that all Sections of the Society note the dates of June 1 and 2 in their Section calendars and take steps to avoid any conflicts in program during these days, so that as many members as possible may be together at the Milwaukee Convention.

1949 SHEWHART MEDAL

Mr. P. L. Alger, Chairman of the Shewhart Medal Committee, has announced that nominations for the 1949 Shewhart Medal may be made by any member of the Society, or groups of members, or Sections, until the closing date of January 31, 1950. Nominations should be sent directly to Mr. P. L. Alger at the General Electric Company, Schenectady, New York.

Any person who, in the opinion of the Shewhart Medal Committee, is noted for outstanding leadership in the field of modern quality control is eligible for the award. This accords with the inscription on the medal itself. Persons who are not members of the Society, both at home and abroad, are eligible, but preference will be given to Society members.

The Shewhart Medal will be presented to the 1949 Medallist at the Milwaukee Convention on June 1, 1950.

In addition to Mr. Alger, members of the Shewhart Medal Committee are: C. A. Bicking, E. L. Fay, I. S. Hoffer, G. R. Gause, A. I. Peterson, W. R. Purcell, C. E. Stines, and P. A. Robert.

BRUMBAUGH AWARD

The Brumbaugh Award Committee is now hard at work reviewing recommendations made by Society members for the first Brumbaugh Award. From these recommendations, the Committee will select the paper published in Industrial Quality Control which is judged to have made the greatest contribution to the development of industrial applications of quality control. Papers published in the magazine from July 1944 to June 1949 are eligible for this year's award.

The first Brumbaugh Award of $50 will be presented at the Milwaukee Convention next June.

Members of the Brumbaugh Award Committee are: H. H. Kent (Chairman), C. S. Barrett, P. D. Deans, J. J. Ferri, Wyatt H. Lewis, H. H. Sheaffer, C. R. Scott, and M. E. Wescott.

Book Reviews

A. C. COHEN, JR., Editor

ELEMENTARY STATISTICAL ANALYSIS

S S. Wilks, Professor of Mathematics, Princeton University. Princeton University Press, Princeton, N. J., 1948: xi+280 pages; $2.50. Review by W. Edwards Deming, Bureau of the Budget, Washington 25, D. C.

At last, here is a real text book for the study of statistics. The science of statistics has made important advances during the past few years, but unfortunately, with but few exceptions, elementary statistical text books, although they have appeared in numbers, have not reflected the newer types of thinking, nor laid a foundation for the same. This book sets new standards.

Correspondence and suggestions concerning book reviews should be sent to
Professor A. C. Cohen, Jr.
Department of Mathematics
University of Georgia
Athens, Ga.

The mathematical level fits the requirements of freshmen at Princeton. The time is past when a first course in statistics, either for intending statisticians or for intending students in quantitative subject-matter, is expected to be completely non-mathematical. The style is clear, and anyone with high school algebra can study the book. The inspiration that a student derives from it may be expected to result in further mathematical and statistical pursuits.

The central theme seems to the reviewer to be the correct one, namely, that statistical data are taken as a basis for action. This is made clear in Chapter 1, the introduction, wherein a number of examples are given in the uses of data. A problem is stated; informa-

tion is needed; how shall the information be obtained? An inquiry shows certain results: what action may rationally be taken on the basis of these results?

It is made clear to the reader that all figures obtained in surveys and experiments are subject to errors of various kinds, but that the reproduceability of the figures may usually be controlled through the design of the sample, the questionnaire, the interviewing, etc. From the start, data are samples. That is, any set of data is but one of many sets of figures that would be obtained if the survey were repeated under the same or varied conditions. A complete census is no exception.

Too often in elementary textbooks the student is taught nothing about the fallibility of data. Too often the numerical problems in statistics are but exercises in arithmetic, not in statistical thinking. Given a set of data, find the mean, standard deviation, quartiles, etc. Here, all such arithmetical manipulations have a purpose in view, namely, *action*: what do the data indicate?

An example will illustrate. One well-known textbook devotes a number of pages to three different arbitrary devices for calculating the median of a distribution, but with no inkling of arbitrariness to the student, who is apparently expected to memorize all three ways, and is apparently expected to believe that all three results are medians. What one does with a median is not mentioned, nor the fact that another set of data would show three new medians. In Wilks book (p. 17) a median is simply the abscissa that corresponds to the ordinate half way up on a cumulative frequency graph.

The book leads into the main elementary problems of the design of samples and experiments, and to problems in the interpretation of the results. A foundation is laid for deeper statistical study. Estimation and tests of significance are treated in Chapters 10 and 11; testing randomness is treated in Chapter 12. Chapter 13, the last chapter, deals with the analysis of pairs of measurements, and contains theory and exercises on various problems of regression and curve fitting. Chapter 4 on elementary probability is excellent.

The theory in the book is abundantly illustrated by many examples, drawn from the author's unsurpassed breadth of experience in a wide range of problems—public opinion, industrial development and numerous examples in the *control of quality*.

The book leads into most of the ordinary modern techniques of design and analysis. The only possible criticism is the omission of chi-square, an omission which was voiced to the reviewer by a friend who is already using the book as a text in his college courses. This omission in the reviewer's opinion is unimportant, and is doubtless intentional on the part of the author.

It is litho-printed from typewritten sheets, very carefully laid out and easily read. This book is destined to become widely used and appreciated, both for teaching and for private study.

NOMOGRAPHY

Alexander S. Levens, Professor of Engineering Design, University of California, Berkeley. John Wiley & Sons, Inc., New York, 1948; 176 pp., 88 illus.; $3.00. Review by David Moskovitz, Professor of Mathematics, Carnegie Institute of Technology, Pittsburgh, Pennsylvania.

This book is intended as a text in the use and construction of alignment charts, and has many examples of such charts selected from all branches of engineering. The text proper begins with Chapter 2 in which are discussed functional scales, adjacent and non-adjacent scales for the solution of the equation $f_1(u) = f_2(v)$. Each of the next eight chapters is devoted to the design of one of each of eight particular types of equations involving three or more variables. Chapter 11 treats seven additional special forms, and discusses the design of net charts. The practical shortcuts in the design of alignment charts of Chapter 12 are of such a nature that they could be independently discovered by any good student who had constructed a few charts. The treatment of the design of alignment charts by the use of determinants in Chapter 13 is inadequate, and anyone wishing to be versed in this method had better consult some one of the references cited in this book. In addition to the many examples in the text proper, there is an appendix with many more examples of charts for formulas from the fields of engineering, production, and statistics. The book abounds with exercises, in fact many more than are necessary. The book is clearly written, and requires but little mathematical background for its understanding.

CONSULTING SERVICES

Responsibility of the American Society for Quality Control, Inc., for Consulting Services advertising is limited to certification that advertisers hold the grade of membership in the Society stated in their advertisements. Qualification requirements for the several grades of membership are set forth in the Constitution of the Society.

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A ten-day intensive training course in Statistical Methods of Quality Control will be offered jointly by The University of Georgia and The Georgia Institute of Technology, at Athens, Georgia, March 6-16, 1950.

Instruction will emphasize basic control charts and sampling methods, but will also cover some of the advanced techniques including design of experiments, correlation, and analysis of variance. Persons enrolling for this course should have a good working knowledge of algebra. Advanced work in mathematics and previous training in statistics are helpful but not necessary.

The tuition of $100.00 per person includes books and supplies. Further inquiries and applications for enrollment should be addressed to Professor A. C. Cohen, Jr., Mathematics Department, University of Georgia.

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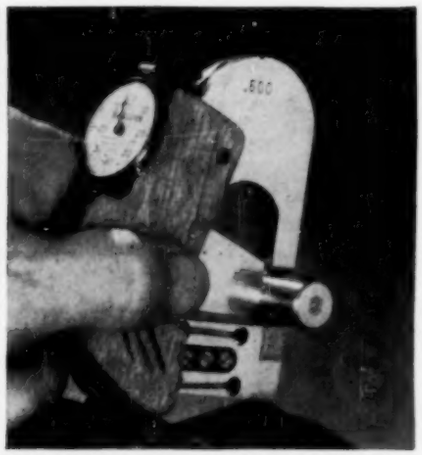

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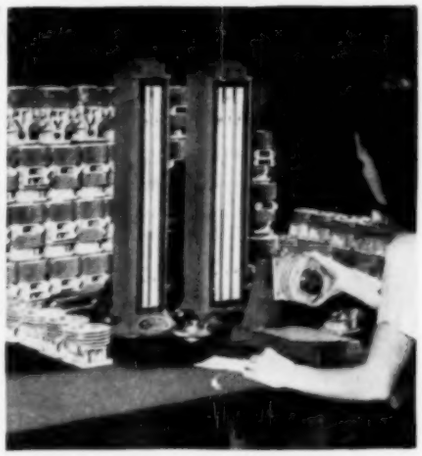

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